

AD-A245 835



DTIC
ELECTE
FEB 11 1992



Approved for public release;
Distribution Unlimited

92-03212



Approved by



Thomas G. Dobie, M.D.
Chairman, Scientific Review Committee

Released by



CAPT Douglas W. Call, MSC, USN
Commanding Officer

Naval Biodynamics Laboratory
P. O. Box 29407
New Orleans, LA 70189-0407

Approved for public release; distribution is unlimited. Reproduction in whole or part is permitted for any purpose of the United States Government.

The interpretations and opinions in this work are the authors' and do not necessarily reflect the policy and views of the Navy or other government agencies.

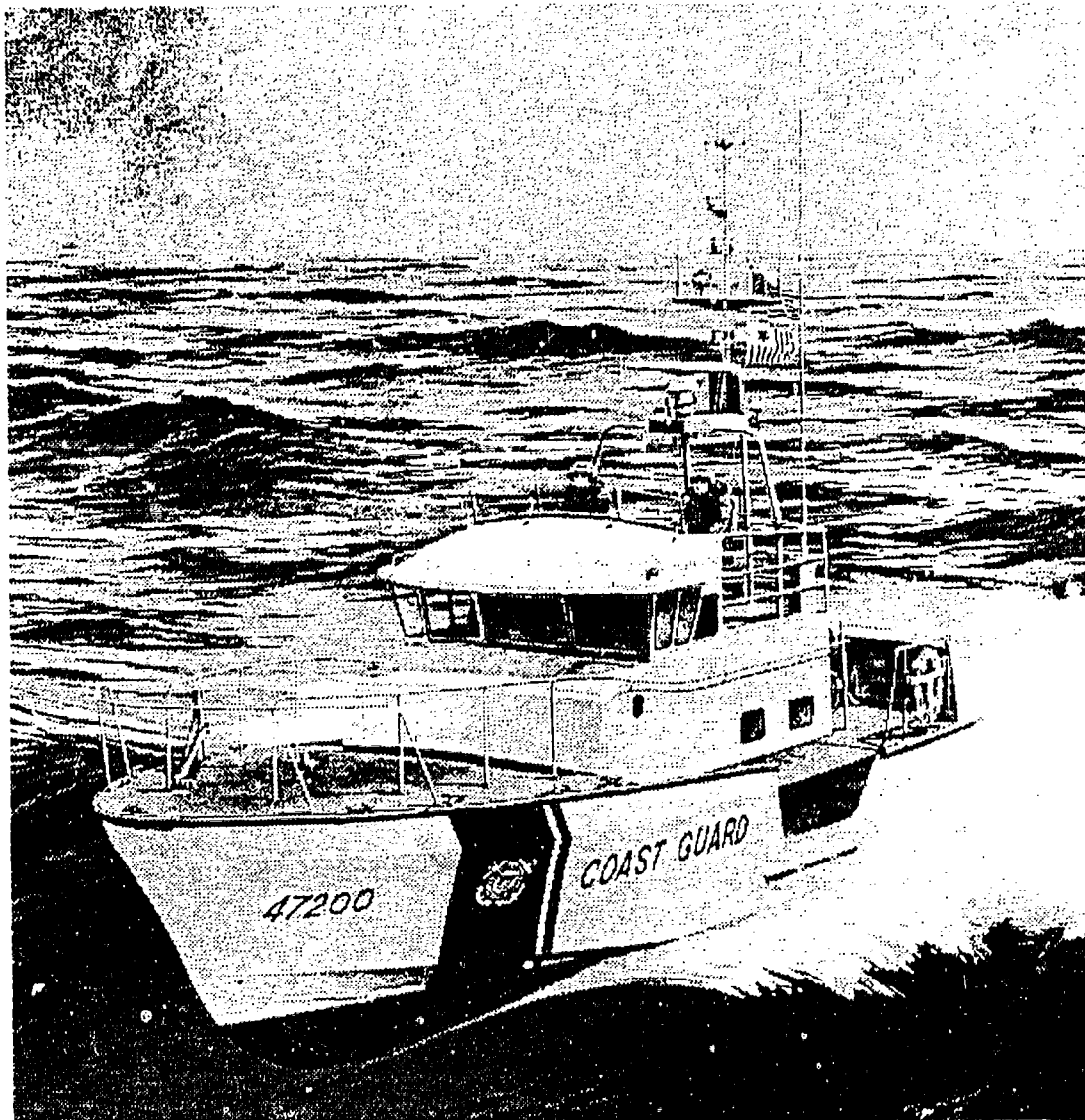
In the interest of precision, trade names of products are cited. These citations do not constitute endorsements of the products.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

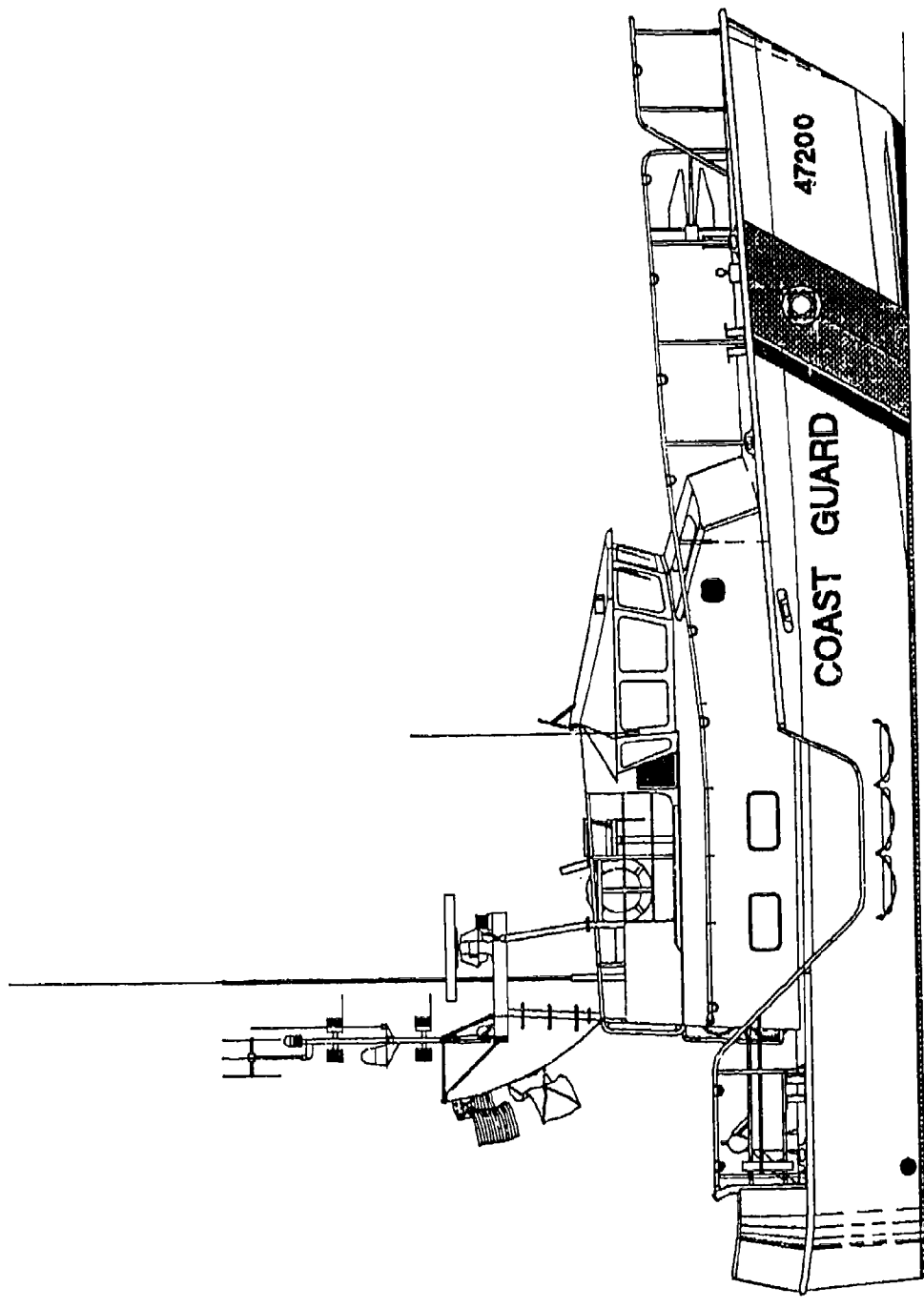
1. AGENCY USE ONLY (Leave Blank)		2. REPORT DATE October 1991		3. REPORT TYPE AND DATES COVERED Interim	
4. TITLE AND SUBTITLE Human Factors Assessment of USCG				5. FUNDING NUMBERS 69X0243	
6. AUTHOR(S) LCDR F. D. Holcombe, MSC, USN and LT S. C. Webb, MSC, USNR					
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Biodynamics Laboratory P. O. Box 29407 New Orleans, LA 70189-0407				8. PERFORMING ORGANIZATION REPORT NUMBER NBDL-91R003	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Commandant, U.S. Coast Guard Office of Acquisition (G-AMB) U.S. Coast Guard Headquarters, Washington, DC 20593-0001				10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES					
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.				12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) Part I documents the ergonomic and safety deficiencies noted during an on-site familiarization and inspection of the prototype 47-ft motor lifeboat. The following human factors operability and habitability problem areas are addressed: steps, platforms, and railings; doors hatches, and passageways; controls; instruments and displays; workspace; and habitability considerations. Approaches to problems are indicated in the form of suggestions for possible redesign, reconfiguration, relocation, or replacement of equipment. Deficiencies fall into these categories: design of ladders; design and configuration of hatches; location and arrangement of controls, instruments, and displays; design of seating; and workspace layout. Part II initiated general and specific recommendations for re-configuration of the open and enclosed steering stations. A structured operational test and evaluation protocol was followed to fully address all human factors problem areas. Mock-ups of the open and enclosed steering stations were constructed for the purpose of evaluating alternative configurations of equipment layout (see Appendix). Criteria were followed to judge the appropriateness and value of all recommendations. First, wherever possible, generally accepted principles of Human Factors Engineering were employed. A second test criterion was the elimination of dysfunctional arrangements, such as one piece of equipment interfering with another.					
14. SUBJECT TERMS Human factors; ergonomics; safety design; environmental design.				15. NUMBER OF PAGES 74	
				16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT		



U. S. Coast Guard 47-ft Motor Lifeboat.



Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	



U. S. Coast Guard 47-ft Motor Lifeboat.

TABLE OF CONTENTS

I: Preliminary Evaluation of Ergonomic and Safety Deficiencies	1
1. SUMMARY AND CONCLUSIONS	2
2. OPERABILITY CONSIDERATIONS	2
2.1 STEPS, PLATFORMS, RAILINGS	2
2.1.1 Forward Deck Railing	2
2.1.2 Ladders/Railings	2
2.2 DOORS, PASSAGEWAYS	6
2.2.1 Doors #1	6
2.2.2 Doors #2	7
2.2.3 Doors #3:	8
2.2.4 Doors #4	8
2.2.5 Doors #5	9
2.3 CONTROLS	9
2.3.1 Start/Stop Switches (Buttons)	9
2.3.2 Throttle Controls	10
2.3.3 Jog Levers (Rudder Controls)	10
2.3.4 Navigation and Exterior Light Panels	11
2.4 DISPLAYS	11
2.4.1 Instrumentation Layout	11
2.4.2 Open Bridge Instruments	11
2.4.3 Engine Indicator Gauges	12
2.4.4 Radar CRT Monitor on the Open Bridge	12
3. HABITABILITY CONSIDERATIONS	13
3.1 CHAIRS	13
3.1.1 Chairs #1:	13
3.1.2 Chairs #2:	14
3.1.3 Chairs #3	14
3.1.4 Chairs #4	15
3.2 CHART TABLE	15
3.3 WINDOWS	15
3.4 OPEN BRIDGE LAYOUT	16
3.4.1 Wire Bundle	16
3.4.2 Junction Box	16
3.5 DECK IN THE FORWARD STORAGE COMPARTMENT	16
3.6 WALK-WAY GRATING OVER THE RESCUE WELL	17
3.7 WORKSPACE	17
II: Proposal for Improvements to Open and Enclosed Steering Stations	19

1. SUMMARY AND CONCLUSIONS	20
2. OBJECTIVE	21
3. OPEN BRIDGE: STARBOARD CONSOLE	21
4. OPEN BRIDGE: PORT CONSOLE	25
5. CHAIRS	30
6. BENCH SEAT	33
7. ENCLOSED BRIDGE LAYOUT	36
8. CONTROLS	43
9. DISPLAYS	45
10. WINDOWS	49
11. HEATING, VENTILATION AND AIR CONDITIONING UNIT AND VENTILATION	53
12. LABELS AND LABELING	53
APPENDIX.....	A-1

LIST OF FIGURES

Figure I.1.	Knobs using surface texture discrimination. Each represents a different textural pattern.	3
Figure I.2.	Appropriate and inappropriate ways of descending a ladder.	5
Figure I.3.	Watertight door with control wheel, extended handle, and dogs.	7
Figure II.1a.	Current starboard steering station on open bridge.	22
Figure II.1b.	Proposed starboard steering station on open bridge.	22
Figure II.2a.	Current starboard steering station on open bridge.	24
Figure II.2b.	Current starboard steering station open bridge dials.	24
Figure II.2c.	Starboard steering station.	24
Figure II.3.	Port steering station open bridge.	26
Figure II.4.	Port steering station on open bridge.	27
Figure II.5.	Proposed port steering station on open bridge.	28
Figure II.6.	Proposed autopilot cutoff switch on open bridge.	29
Figure II.7.	Chair footrest.	31
Figure II.8.	Proposed footrest on open bridge starboard steering station.	32
Figure II.9.	Chair with "wraparound" backrest and adjustable armrest.	34
Figure II.10a.	Front lateral view with four point seat restraint configuration.	35
Figure II.10b.	Front lateral view with proposed seat restraint configuration.	35
Figure II.11.	Wide angle view of enclosed bridge.	37
Figure II.12.	Proposed layout of enclosed bridge with jog levers.	38
Figure II.13.	12 volt DC panel starboard bulkhead of enclosed bridge and starboard jump seat.	39
Figure II.14a.	Portside of the enclosed bridge ladder and jump seat.	39
Figure II.14b.	Portside jump seat and shore tie.	39
Figure II.15.	Aft window of the enclosed bridge battle lantern and hydraulic fluid reservoir.	41
Figure II.16.	Proposed enclosed bridge with two sets of jog levers and throttles.	42
Figure II.17.	Proposed enclosed bridge layout.	44
Figure II.18a.	Radar plotter screen.	46
Figure II.18b.	Centerline console.	46
Figure II.18c.	Throttle control, Loran C and other controls.	46
Figure II.19.	Proposed relocation of radar plotter.	47
Figure II.20.	Wet compass and window wiper controls.	48
Figure II.21.	Gauge formats.	50
Figure II.22.	Window/heaters junction box in enclosed bridge overhead.	52
Figure II.23.	Open bridge navigation and lighting switch panel.	55

Figure II.24a.	Current navigation and lighting switch panels on open bridge.	56
Figure II.24b.	Proposed navigation and lighting switch panels on open bridge.	56
Figure II.25.	Proposed navigation and lighting switch panel with LEDs.	57
Figure II.26.	Color codes for engine indicators.	58
Figure A1.	Enclosed bridge steering station mock-up (actual configuration).	A-1
Figure A2.	Enclosed bridge steering station mock-up (actual configuration).	A-2
Figure A3.	Enclosed bridge steering station mock-up (proposed configuration).	A-3
Figure A4a.	Current starboard open bridge steering station mock-up.	A-4
Figure A4b.	Proposed starboard open bridge steering station mock-up.	A-4
Figure A5.	Port open bridge steering station mock-up (proposed configuration).	A-5

HUMAN FACTORS ASSESSMENT OF USCG 47-FT MOTOR LIFE BOAT

I: Preliminary Evaluation of Ergonomic and Safety Deficiencies

1. SUMMARY AND CONCLUSIONS

This report documents the ergonomic and safety deficiencies noted 14-16 November 1990 during an on-site familiarization and inspection of the prototype USCG 47-ft motor lifeboat (MLB). The following human factors problem areas are addressed: steps, platforms, and railings (including ladders); doors, hatches, and passageways; controls; instruments and displays; workspace; and habitability considerations (including chairs).

Wherever possible, approaches to problems are indicated in the form of suggestions for possible redesign, reconfiguration, relocation, or replacement of equipment. Please note that these recommendations are tentative and addressed to specific problem areas. To provide the best *package* of recommendations the following will be required: additional in-depth analysis of the noted deficiencies, analysis of the interactions among various functional areas, and consideration of superordinate solutions affecting several functional areas.

The majority of deficiencies fall into these categories: design of ladders; design and configuration of hatches; location and arrangement of controls, instruments, and displays; design of seating; and workspace layout. While some of the noted deficiencies lack complete specification at this stage, only two major areas will require significant additional study: the location and configuration of the aft crew seats in or near the enclosed bridge, and the redesign of the survivors compartment-to-aft deck passageway, eliminating the open bridge bench seat.

We hope that these observations will be of immediate value in finalizing the design and acquisition of the proposed fleet of 47-ft motor lifeboats.

2. OPERABILITY CONSIDERATIONS

2.1 STEPS, PLATFORMS, RAILINGS

2.1.1 Forward Deck Railing

In general, forward deck railings are very good. Hand railings in their present configuration afford safe crew movement about the deck. A "gap" in the railing adjacent to the forward storage compartment would provide easier access to the compartment.

2.1.2 Ladders/Railings

Item #1. The ladders leading to and from the open bridge (OB), enclosed bridge (EB), and survivors compartment (SC) are functional, but require design changes. The slope of the steps leading to the EB and the steps leading to the OB are very close to 50° or more. In this case, the crewmember cannot decide whether to step down facing toward or away from ladder.

Problem:

- Tread depth, riser height, and stringer angle are not standardized throughout the boat. The surface of the tread (diamond-stamped pattern) is not appropriate, especially when the ladder is wet. The

Human Factors Assessment of USCG 47-ft MLB

hand rails in the EB are squared off at the ends; they are slippery when wet and may compromise the safety of the crew.

Approach:

- In all three cases, treads should be covered with a nonslip material that allows the slight sliding motion that is necessary to safely climb such steps. Since the step angle is steep, a nonslip surface would provide better traction for the crew in rough sea states.
- Tread depth, riser height, and stringer angle should follow standard human factors engineering guidelines.
- The EB railing should be curved at the ends to provide better handling and safety.
- The railing should have a nonslip surface (i.e., knurled texture) for proper grip and crew safety. This is recommended for all railings in the 47-ft MLB (see Figure I.1).

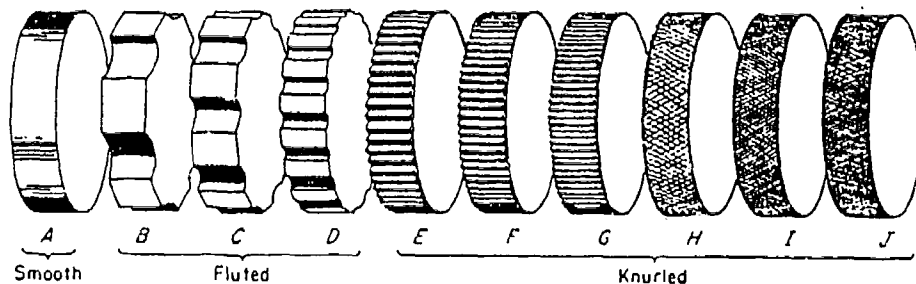


Figure I.1. Knobs using surface texture discrimination. Each represents a different textural pattern.

Item #2. The ladder from the SC to the aft deck has three steps.

Problem:

- There is a potential danger of slipping on the steps when they are wet and injuring oneself by catching a foot on the side of the steps, or accidentally kicking or stepping on the fuel cut-off switch located near the steps.

Approach:

- Provide a safety screen behind the steps to prevent slipping accidents/personnel injury. Provide a true ladder rather than separate steps to prevent slipping off the steps.

NAVAL BIODYNAMICS LABORATORY REPORT

- Fuel cut-off switch should be relocated or covered rather than left exposed.
- If possible, all ladders and steps throughout the 47-ft MLB should be standardized, especially the tread and riser configuration.

Item #3. The ladder extending from the aft deck to the OB follows recommended design guidelines, having round and head features to ensure maximum flexibility and adequate safety.

Caution: Crewmembers should be discouraged from facing away from the ladder while descending (see Figure I.2). A potential for injury exists, both by falling from the ladder and by falling into the towing bit located on this aft deck.

Problem:

- In addition the aft ladder does not have a safety restraint or line across its top. This is potentially dangerous for personnel, especially during rough seas.

Approach:

- An easily movable gate with double bars placed level with the current safety railing would be preferred. Ideally, the gate would be constructed of the same material as the railing and hinged to swing in the desired directions and could be secured in both open and closed positions.
- As an alternative a safety bar may be provided across the ladder access way to prevent crewmembers from falling to the deck below.
- Additional handholds should be provided as braces for the crew. These should be attached along the side and underneath the mast platform. This overhead handhold will allow crew to steady themselves at two points: railing and overhead.

Item #4. The forward ladder in the recessed decks is a potential problem.

Problem:

- If the steps are wet, a slipping/falling hazard exists.

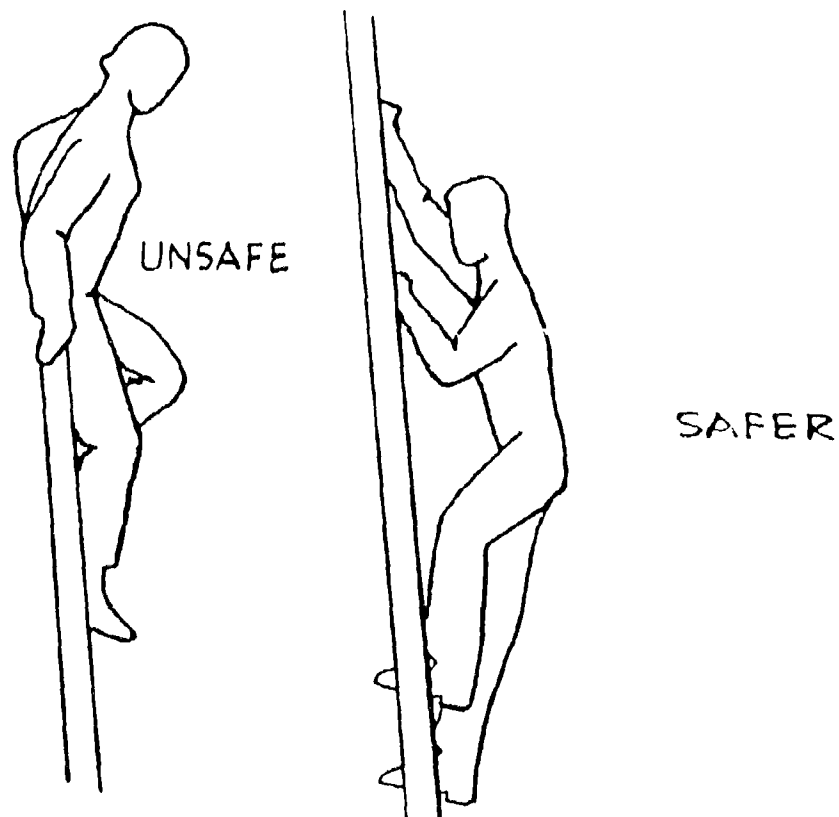


Figure I.2. Appropriate and inappropriate ways of descending a ladder.

Approach:

Minor improvements are recommended:

- Provide a safety screen behind the ladder (steps) to prevent slipping between the steps.
- Curb or round off the aft deck step to prevent crew from tripping "up" the ladder/steps. Aft platform should be flush with the end of the riser, thereby eliminating the tripping hazard.
- The "lips" of the deck meet the grating of the recessed deck. However, the end of the grating deck should be extended and closed, if possible.
- Install a railing on the bulkhead just below the recessed deck grating in order for crew to brace themselves in a kneeling position while recovering overboard people or objects.
- This railing should extend 4 inches from the bulkhead for hand clearance; the railing would also afford more flexibility than the "D" ring restraints; top of aft platform is a knife edge.

NAVAL BIODYNAMICS LABORATORY REPORT

Item #5. Handholds in the OB area.

- Problem:**
- During rough seas, topside crew encounter instability. Handholds are necessary for standing crewmembers to brace themselves while working in the OB space. Crewmembers may be tempted to grab the radar platform, coxswain chairs, etc.
- Approach:**
- Grab bars should be installed on the radar platform (overhead) in order for crew to brace themselves during rough sea conditions.

2.2 DOORS, PASSAGEWAYS

2.2.1 Doors #1

Access to the open bridge (OB) from the enclosed bridge (EB) is through a 36 × 22-inch watertight door. The door swings open to port. Crew passing from EB to OB are required to climb up the ladder, push the door open (after unsecuring it), grip the handrails on the bulkhead, and hold the door steady until they are on the OB deck. In the opposite direction (OB to EB) crew are required to unsecure door and hold it open, grip the handhold on the bulkhead and step down to the ladder.

- Problem:**
- Potential for personal injury exists while crew pass through the door. Crew are required to hold the door with one hand, grab the handrail with the other, and walk up the ladder simultaneously. In rough seas crew will not be able to maintain positive control, thereby increasing the risk of injury.
 - The door impedes the movement of the port OB chair.
 - The bolts of the door are exposed and present a hazard to the crew passing through the door. Crewmembers have reported minor injuries due to these bolts.
- Approach:**
- The door should be designed with a self-locking mechanism to secure the door in an open position. This mechanism is recommended for all doors.
 - All doors are operated at once by the extended handle located on the control wheel of the watertight door. The handle will provide positive control for the crew (see Figure I.3).
 - Grab handles should be placed over the doors and on both sides of the door.
 - Additional positive control of the door can be gained by installing a handhold/grip on both sides. Currently, crewmembers are required to open the door and hold it open (with the dog handle) while climbing up the ladder.
 - Recess, cap, or remove threads from the end of the bolts to eliminate the workspace hazard.

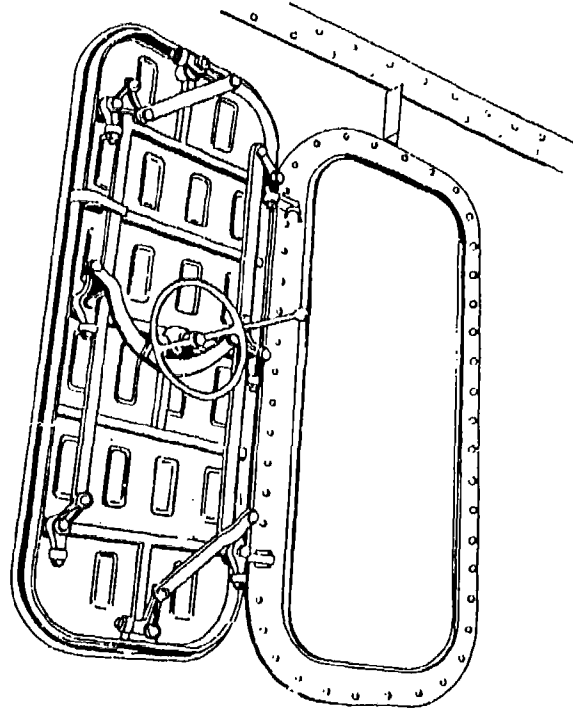


Figure I.3. Watertight door with control wheel, extended handle, and dogs.

2.2.2 Doors #2

Access to the EB from the survivors compartment (SC) is through a 30 × 24-inch watertight door. The door swings starboard. Crew passing through the door from the SC to the EB must stand on the SC deck and open the door, hold the door open while climbing three steps, and secure the door from a position on the EB deck. The door does not open with a single motion; crew are required to push the angled door open before passing through it. The door can be locked from both sides; it has a uniform open/close dog mechanism.

Problem:

- Crew passing from the SC to the EB are required to grasp the dog mechanism to positively control the door. In rough sea conditions, control will be compromised.

Approach:

- Self-locking mechanism should be provided so that there is a means for securing the door while crewmembers pass through the door.
- Install a vertical grab bar on the door.
Handhold length: 6 inch minimum.
Handhold opening: 6 × 4 inch minimum.

NAVAL BIODYNAMICS LABORATORY REPORT

Handhold opening: 6 x 4 inch minimum.

Handhold should not obstruct dog locking mechanism.

- Replace/redesign dogs.

2.2.3 Doors #3:

Access to the auxiliary machine space from the SC is through a 39 x 24-inch watertight door, which swings to port. Door opens/closes using the standard mode of dog handle operation and is lockable from both compartments.

Problem:

- Crewmembers are required to open door, push door open, grasp handhold over door, step down into compartment, and control door before securing it. Stepping down into the compartment is difficult at best.
- The handhold is close to the piping and flanges on the bulkhead and this arrangement may present a potential hazard to crewmembers passing through the door.

Approach:

- Installation of vertical grasp bar on the door.
- Remove a panel section from the SC deck (aft of the door) to provide additional access and flexibility.
- Self-locking mechanism should be provided so that there is a means for holding the door open.
- If possible, all doors should be uniform in configuration.

2.2.4 Doors #4

Access to the SC from the aft deck is through a 60 x 24-inch watertight door. The door swings starboard and inward. Watertight doors typically open against the pressure of water flow, ensuring their watertight integrity. A three-step ladder allows entry and exit from the SC to the aft deck.

The size of the door is adequate for crew and survivor passage. However, the door is not wide enough to accommodate a 23.5 x 84-inch Stokes litter with flotation devices (in the case of an incapacitated survivor) without tilting the litter significantly to clear the passage through the door.

Problem:

- Crew exiting the SC to the aft deck are required to unsecure the door (via dog mechanism), step back down the ladder in order for the door to clear the threshold/platform, hold the door open when passing through to the aft deck; and resecure the door (pulling action). Door requires considerable force and awkward movements to secure it.
- Information (i.e., labeling) regarding securing/unsecuring the door is not provided on the aft deck side. Crew are required to secure the door by pulling it closed while latch/dogs are in unlocked position. Instead of moving latch in a clockwise direction, the door/dogs secure by moving the latch in a counterclockwise motion.

Human Factors Assessment of USCG 47-ft MLB

- Experienced crewmembers are familiar with doors that open outboard and are secured with a continuous motion of the hand. Generally, exterior securing doors should open outboard so that crew are minimally hindered in the event of an emergency exit.

Approach:

The safe use of the door can be ensured by:

- Reconfiguring the door to open outward (to ensure watertight integrity and facilitate emergency escape).
- Changing the locking/dog configuration.
- Equipping door with self-locking mechanism in order to keep it open to communicate with crew/survivors while underway.
- Padding the top of the door jam to lessen the possibility of head injury when crew or survivors pass through the door.
- Decrease the width of the Stokes litter, if possible, so that it can pass through the door safely.

2.2.5 Doors #5

The door to the engine room measures 36 x 22-inches.

Problem:

- Crewmembers experience the same positive control problems as with other doors.

Approach:

- The door should be designed with a self-locking mechanism to secure the door in an open position while crewmembers are passing through.

2.3 CONTROLS

2.3.1 Start/Stop Switches (Buttons)

The arrangement of instruments on the open bridge (OB) and enclosed bridge (EB) lack uniformity. Ideally, all controls should be functionally related and arranged so that they are in the same general position at each steering station.

Problem:

- The engine start and stop buttons are located in three different positions on the EB and OB consoles.

Approach:

- The start/stop switches should be located where they are most accessible for the coxswain to control.
- On the OB starboard console, the start/stop buttons are on the console, requiring the coxswain to reach around the steering wheel and throttle to engage the switches. Separate start and stop switches should be installed in a uniform manner on all three consoles.

NAVAL BIODYNAMICS LABORATORY REPORT

2.3.2 Throttle Controls

The throttle control is easily accessible and equally convenient to both coxswain positions.

Problem:

- The throttles are located in different panel positions in the OB steering station. The desired/recommended configuration is on the starboard console. The throttle is located to the right of the steering wheel and is in an effective and safe position. The port console throttle is located directly in front of the coxswain. *This position is unsafe and not recommended.* In this position, the possibility of an operator/coxswain impacting it (during rough water operations) exists.

Approach:

- The throttle on the OB port should be positioned outboard on the panel to prevent crew from inadvertently grabbing it during rough seas.
- In addition, positioning it outboard and to port of the coxswain's position would be a safer throttle arrangement.
- The throttle should be designed with a lock-out mechanism to prevent it from becoming engaged while the MLB is being steered from another steering station.

2.3.3 Jog Levers (Rudder Controls)

The jog lever control has $\pm 30^\circ$ of movement. Continuous control inputs are not required to maintain a turn; control input remains "in" until canceled by opposite control input. Inside the EB, the coxswain's control lever is attached to the end of the outboard (opposite) arm of the chair; the engineer's lever is located on the outboard arm. In both cases the lever is oriented in the vertical plane and moves laterally. In the OB there are two additional levers, but they are oriented in the horizontal plane with the lever pointing aft. Push the lever to the right and the boat turns right; push left, the boat turns left.

Problem:

- EB jog levers are positioned on a vertical plane while the OB jog levers operate on a horizontal plane. This may be confusing when the operator suddenly changes from OB to EB steering stations or vice versa.
- The levers on the armrests do not allow the coxswain to stand and operate the levers comfortably.
- One human factors engineering issue is whether the lever characteristics allow the coxswain to adequately control the boat during critical maneuvers.
- Another issue is whether equal steering performance will be obtained across the EB and OB configurations. Steering performance may not be equal for the two steering/control configurations.
- The cord from the jog lever in the EB gets tangled in the chair adjustment button.

Human Factors Assessment of USCG 47-ft MLB

- Approach:**
- Relocate the jog levers to the console in the preferred horizontal position.
 - Eliminate the jog lever on the starboard side of the OB.

2.3.4 Navigation and Exterior Light Panels

Location of the navigation and exterior light panel is bottom aft on the EB centerline console.

- Problem:**
- Reaching causes coxswain operators to shift their normal operation position; it requires that they look for the controls and take their attention away from underway procedures, during which they may miss an important instrument reading.
 - The light switch panel configurations are alike on the EB and OB. However, the open bridge switches functioned in an opposite manner from the instruction labels. In other words, the off position of the switch activated the light and vice versa.

- Approach:**
- The navigation and exterior light panel could be positioned in the EB overhead. This would increase accessibility of the panel to the coxswain's steering station.
 - A simple rewiring of the OB panel will remedy the problem of reversed switches.
 - The panel on the OB can be moved closer to the centerline to allow for more space on the radar enclosure.

2.4 DISPLAYS

2.4.1 Instrumentation Layout

The electrical heading indicator and the rudder angle indicator are located both port and starboard on the enclosed bridge (EB) dashboard. Such duplication is unnecessary.

2.4.2 Open Bridge Instruments

The current arrangement of the open bridge (OB) starboard steering station provides both a steering wheel and jog lever as a backup control. Emergency fuel cut-off switches are placed below the starboard panel, providing access for the port coxswain position.

- Problem:**
- The fathometer, digital compass, and the autopilot control are obstructed by the hand microphone cords.

- Approach:**
- Eliminate the jog lever from starboard steering station. The jog lever on the port steering station will serve as a "back-up" steering mechanism.
 - Relocate the hand microphone in order for the coxswain to reach for the microphone without looking for it while operating the boat. A

NAVAL BIODYNAMICS LABORATORY REPORT

microphone selector switch would eliminate the need for two microphones at the station.

- Move the directional compass to the left of the radio access window. This arrangement provides the coxswain a direct line of sight to the compass (without obstruction).
- This arrangement allows controls to remain within a few inches of the normal hand position while operating the MLB. Coxswains will not experience control interference when the directional compass is moved to the left of the radio access window.

2.4.3 Engine Indicator Gauges

The EB control panel follows a fundamental rule of instrument layout. It groups the water temperature, oil pressure, and gear oil pressure gauges. They relate to a single system and are arranged so that they are in the same general area on the dashboard.

Problem: • The temperature and pressure indicators on the OB port console are not arranged in the same manner as the EB indicators.

Approach: • In order to bring about standardization of the consoles, the indicators should be grouped in a similar fashion.
• EB water and oil gauges should be relocated toward the port side. Radar should be moved to the (navigation) starboard side and closer to the chart deck/rack; fuel gauge should be moved to the center.

2.4.4 Radar CRT Monitor on the Open Bridge

The radar CRT monitor is part of the instrumentation panel on the OB.

Problem: • The CRT exhibits considerable display "wash out" due to ambient sunlight conditions. In addition, the handle to open the watertight glass cover does not open with a smooth movement.

Approach: • Given the wide operating range of ambient illumination conditions (from full daylight to full dark), human factors engineering tests will ensure that the required visual display characteristics exist, allowing proper performance of the CRT tasks (e.g., adequate symbol-background contrast, CRT glare not excessive).
• Install mechanism that opens the cover with one easy movement.

3. HABITABILITY CONSIDERATIONS

3.1 CHAIRS

3.1.1 Chairs #1:

The enclosed bridge (EB) includes two forward, off-center seats with controls and equipment located on the front instrument panels and a centerline console between the two seats. The seats are standard Turnbull type. Each seat has retractable armrests.

The seat dimensions are: 19.5 inches back-to-front; 18.5 inches wide; 23 inches wide including armrests, 26 inches wide including steering controls (jog levers). The back of the chair is 33.5 inches from the EB aft bulkhead with the chair in the forward position, and 26.5 inches with the chair in aft position.

There is a 6-inch, fore-aft adjustment to increase the ease of access to the seat. The armrests rotate from the horizontal to a vertical position to facilitate access into the seat.

Vertical adjustments are provided so that crewmembers can seek their own optimal seat height. There appears to be adequate overhead clearance for the operators.

Problem:

- The chair adjustment device is located on the aft seat pedestal/stand, making it inaccessible while the member is seated. Armrests, in addition to reducing fatigue, help secure the coxswain against lateral forces incurred during rough seas. Crew entering or exiting seats from the forward position incur extreme difficulty in clearing the center console. There is minimal knee/leg clearance (less than 2 inches) due to the center console. The coxswain is required to move the seat/chair to the aft position and swing out to exit the chair. Crew outfitted in mustangs or foul weather gear may find it difficult to enter and exit the chairs. In this type of gear, crewmembers report less than marginal comfort in the chairs. In emergencies crew safety may be compromised.
- Footrests appear to be marginally adequate. There seems to be no clear reason to have two footrests on each side in the EB. Footrests should be provided to maintain acceptable foot-to-seat height relationship (approximately 16-20 inches from the pan of the chair).
- Chair padding: Crew exposed to whole body vibration may require firmer padding on the pan of the chair and on the backrest. This would increase comfort and decrease the risk of injury.

Approach:

- Adjustment handles should always be designed and located so that crewmembers can use them easily and without risk of personal injury. Operators often need to be in normal operating positions to make a proper seat adjustment. Making them lean over does not help.

NAVAL BIODYNAMICS LABORATORY REPORT

3.1.2 Chairs #2:

One jump seat (fold-up seat) is on the starboard bulkhead just forward of the survivors compartment (SC) door access. The other jump seat is in the aft port corner (adjacent to the port bulkhead). Lap seat restraints are located at each seat. The port side jump seat is located 2-3 inches from Power Panel B (electrical connection board). This port-side 24v electrical panel protrudes approximately 11 inches from the bulkhead and is 24 inches wide.

Problem:

- The jump seats as presently configured are inadequate for crew use. They are in an unsatisfactory location and block the movement of the two coxswain chairs. The starboard jump seat, for example, must be stowed in order for the coxswain to exit the chair.

Approach:

- Eliminate the jump seats from the EB, if possible.
- Relocate the electrical panel to the auxiliary machine room. This would help open up needed space in a severely cramped area.
- Jump seat padding: crew exposure to whole body vibration may necessitate firmer padding on the pan and backrest of the seat. This would increase comfort while reducing fatigue and the possibility of injury.

3.1.3 Chairs #3

The open bridge (OB) includes two chairs, one port and one starboard, which are standard Turnbull type with retractable armrests.

Problem:

- The chairs should lock into position at least every 45°, rather than only at 90° intervals. This would provide the coxswain with more flexibility and stability in the seated position. Crewmembers prefer to have footrests with which to brace themselves during rough seas.
- While walking about the deck, crewmembers have a tendency to grab the chair arms in rough seas. Since these are not lockable, they make poor handholds.

Approach:

- Footrests are required in order for crew personnel to brace themselves during rough sea conditions; footrests in two positions would increase the safety of the members in the OB. In addition, providing footrests would decrease overall fatigue.
- Firmer padding is required, similar to the padding needed in the EB chairs.
- The bench-like seat located starboard and aft of the coxswain chair appears to be adequate for crewmembers. However, in rough seas, handholds are necessary for crew to brace themselves.

Human Factors Assessment of USCG 47-ft MLB

3.1.4 Chairs #4

The SC has seating for five people, three on the port side and two on the starboard. The jump seats are cushioned and equipped with restraining belts. The seats fold up to the bulkhead for storage and access to the removable deck panels.

- Problem:**
- The seats are only marginally serviceable. The hinge brackets on the seats do not allow passengers and crew to lie across the seats.
- Approach:**
- Replace jump seats with fold-down type benches.
 - Assure that standard anthropometric measurements are utilized in the design of the replacement benches.

3.2 CHART TABLE

A fold-up chart table is located on the starboard bulkhead, adjacent to the starboard steering station.

- Problem:**
- Current configuration makes the chart table difficult to use. The coxswain has difficulty pulling the out chart table and then returning it to its stowage area. While in use, the table interferes with the rotation of the starboard chair.
- Approach:**
- The table should be a pull-out type rather than the current fold-up type.

3.3 WINDOWS

In the enclosed bridge (EB) there are four windows forward of the gauge panel/dashboard, two windows on the portside, two windows on the starboard side, and three windows aft. The windows directly port and starboard of the EB crew chairs provide the crew with optimal visibility to the outside. The coxswain and crew are able to see in sitting and standing positions from the EB. The windows both port and starboard are hinged at the top and open out at the bottom.

- Problem:**
- Incorrect operation of the windows has been reported by the test crew. In order to open the windows, crewmembers are required to reach over electrical panels and frame flange to manipulate the window by hitting it; the window release mechanism must be pushed forcefully or struck to effectively open the window.
 - Placing windows where it is difficult to open or close them is a safety flaw.

- The top-hinged windows in the open position may cause a hazard since they are near outside walkways (port and starboard), where crewmembers are walking and working.

Approach:

- To avoid the difficulties involved in opening these windows, the opening mechanisms on the windows should be relocated to the windows aft of the forward chairs. This will provide easier access to the opening. Removal of the frame flange would eliminate the pinch hazard.
- Enlarge and lengthen handle to increase leverage.

3.4 OPEN BRIDGE LAYOUT

3.4.1 Wire Bundle

The wire bundle currently running along the port strut presents a tempting handhold. Concern exists that this wire bundle is not strong enough for this purpose and will break loose from its mounting. For protection, these wires should be enclosed within the strut to the mast, or a shield should be made to incorporate the strut and cables into one unit.

3.4.2 Junction Box

The junction box is currently located on the open bridge near the aft railing. Ideally this would be relocated to the survivors compartment, opening the area for a second bench seat or chair. As an alternative a shield should be provided to enclose the box along the top and sides of the unit, protecting the crew from injuring themselves on the exposed metal edges and wire plugs. This would also decrease the possibility of mechanical failures from damaged plugs and wires.

3.5 DECK IN THE FORWARD STORAGE COMPARTMENT

The deck grating in the forward storage compartment is on two levels.

Problem:

- When the deck is wet, a slipping hazard exists. Several test crewmembers reported a hazard while in the space. One level of grating extends two frames and then rises sharply 2 inches in the next two frames.

Approach:

- Level the grating deck throughout the forward compartment. A gentle slope of the grating deck would virtually eliminate the potential hazard.
- Install nonslip surface to deck.
- Install several handholds in the overhead to allow the crew to brace themselves.

Human Factors Assessment of USCG 47-ft MLB

- Close or cap the ends of the grating deck.

3.6 WALK-WAY GRATING OVER THE RESCUE WELL

The grating can be secured in the up position during personnel recovery operations. However, this task requires inserting a pin (attached to a lanyard to prevent loss) through a hole in a small shaft to ensure that the grating does not fall down.

Problem:

- During rough seas, crewmembers have difficulty raising, lowering, and securing this grating.

Approach:

- A human factors engineering verification test would ensure that the task of securing this grating can be performed safely in rough seas by crewmembers.
- A securing latch device with two levers may be easier to operate. One would allow the grating to be moved to the up position where the grating automatically locks in place and the other lever would release the grating for movement to the down position.

3.7 WORKSPACE

The center console, located on the centerline of the enclosed bridge (EB), is 12.5 inches wide, 37.5 inches high, and 25.25 inches long.

Problem:

- The center console seems necessary for the placement of the throttles.
- Some of the controls and/or switches are not accessible to both steering stations.
- The console significantly decreases the level of mobility of the crew during at-sea operations in the EB.
- The centerline console presents an entering and exiting obstacle to crew seated in the chairs.

Approach:

- The center console should be eliminated from the current design.
- The instruments located on the console should be placed and arranged in the front dashboard and on the overhead.

This page is intentionally left blank.

HUMAN FACTORS ASSESSMENT OF USCG 47-FT MOTOR LIFE BOAT

PART II: Proposal for Improvements to Open and Enclosed Steering Stations

Note: Some of the evaluations and recommendations from Part I are repeated in Part II.

1. SUMMARY AND CONCLUSIONS

Following a preliminary evaluation of ergonomic and safety deficiencies of the prototype 47-ft motor lifeboat, phase two of this human factors assessment was initiated to develop general and specific recommendations for re-configuration of the open and enclosed steering stations. A structured operational test and evaluation protocol was followed to fully address all pertinent operability and habitability considerations, including: controls; displays; workspace; steps, platforms, and railings; doors, hatches, and passageways; labels and markings.

For each of the above considerations, human factors engineering assessment procedures were followed to carefully evaluate each of the following characteristics:

- Location and arrangement
- Size and shape
- Direction and force of required movements
- Information requirements
- Visibility
- Use conditions (motion, lighting, etc.)
- Safety
- Convention (common practice)

A full scale mock-up of the open and enclosed steering stations was constructed for the purpose of evaluating alternative configurations of equipment layout. This mock-up includes movable, actual-size instrument panels, gauges, controls, etc., and allows any possible arrangement of components (see Appendix).

In general two criteria were followed to judge the appropriateness and value of a recommendation. First, wherever possible, generally accepted principles of human factors engineering were employed. A principle of display grouping, for example, suggests that more important and more frequently used instruments should be placed in more readable locations, where most expected, and close to other related controls and instruments. Instruments and controls which are duplicated within a steering station or located at the other stations, such as engine start and stop buttons, should have the same arrangement at each location. A second test criterion was the elimination of dysfunctional arrangements, such as where one piece of equipment obscured another.

The major recommendations for improving the open and enclosed steering stations are summarized as follows:

- ▶ Open bridge starboard panel/console layout is changed to adhere to design principles; spray shield is added; jog lever is eliminated.
- ▶ Open bridge port panel/console layout is changed as above; autopilot cutoff switch is added.
- ▶ Toggle switches throughout both stations are standardized.
- ▶ Chairs and bench seats specifications are redeveloped.
- ▶ Enclosed bridge panel/console layout is changed per design principles as above;

Human Factors Assessment of USCG 47-ft MLB

- ▶ protruding center console stand is replaced with smaller attachment to main panel.
- ▶ Jog levers are re-specified and relocated.
- ▶ Recommendations for auxiliary equipment within the steering station spaces are developed.

2. OBJECTIVE

The objective of the human factors engineering (HFE) assessment of the U. S. Coast Guard 47-ft motor lifeboat prototype is to propose designs for a work environment which fosters effective performance, work patterns, and crew safety and health, and that minimize factors which degrade human performance or increase error.

The open and enclosed bridge consoles have been redesigned so that operator workload, accuracy, mental processing, and communications requirements do not exceed operator capabilities.

HFE proposals for the open and enclosed bridges will reflect design factors that affect crew performance, including:

- ▶ Adequate space for personnel, their equipment, and crew activities during operational and maintenance tasks underway.
- ▶ Adequate physical and visual contact between crew, and between crewmembers and their equipment during underway conditions.
- ▶ Where applicable, the design of open and enclosed bridges should allow personnel to share equipment, reduce communication requirements, conduct required face-to-face communications, and minimize mutual interference when operating controls.
- ▶ Efficient arrangement of operation and maintenance workspaces, equipment, controls, and displays.
- ▶ Provisions for ensuring safe, effective task performance with safeguards against injury, equipment damage, and disorientation.
- ▶ Design features to assure rapid entrance and exit, safety, ease, and economy of operation and maintenance on the open and enclosed bridges.
- ▶ Compatibility of the design, layout of controls, displays, and workspaces with the clothing and personal equipment worn by the crew.

3. OPEN BRIDGE: STARBOARD CONSOLE

Figure II.1a represents the current layout of the starboard console on the open bridge. The layout of the starboard console (primary steering station) provides both a steering wheel and a backup jog lever steering control.

Problem:

- All controls and displays viewed and controlled by the operator are not clearly visible from the normal operating position (seated). In

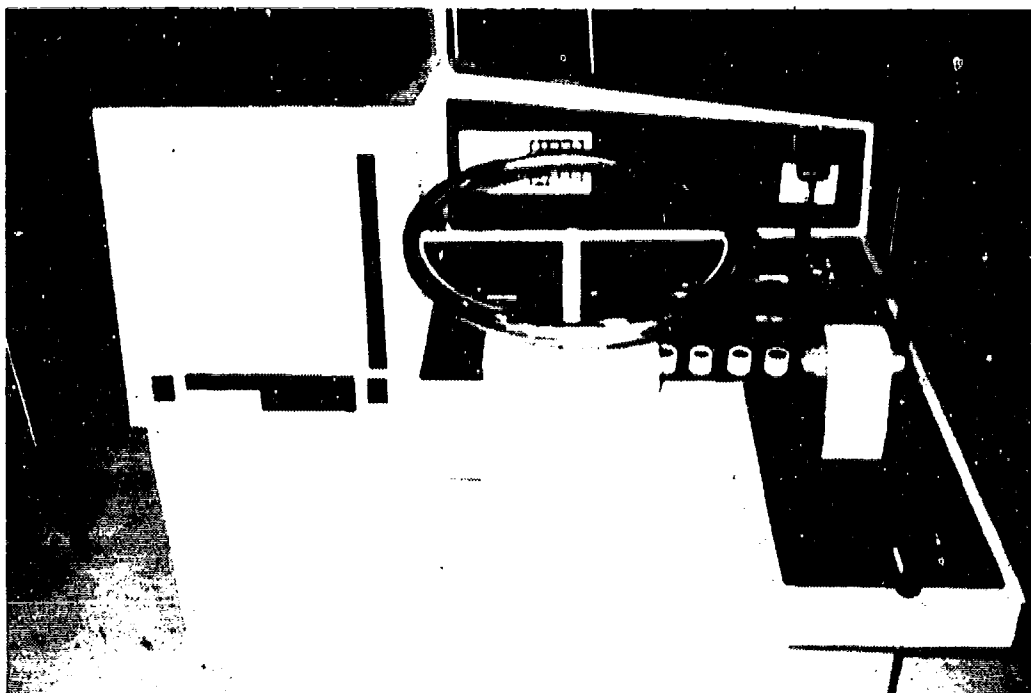


Figure II.1a. Current starboard steering station on open bridge.

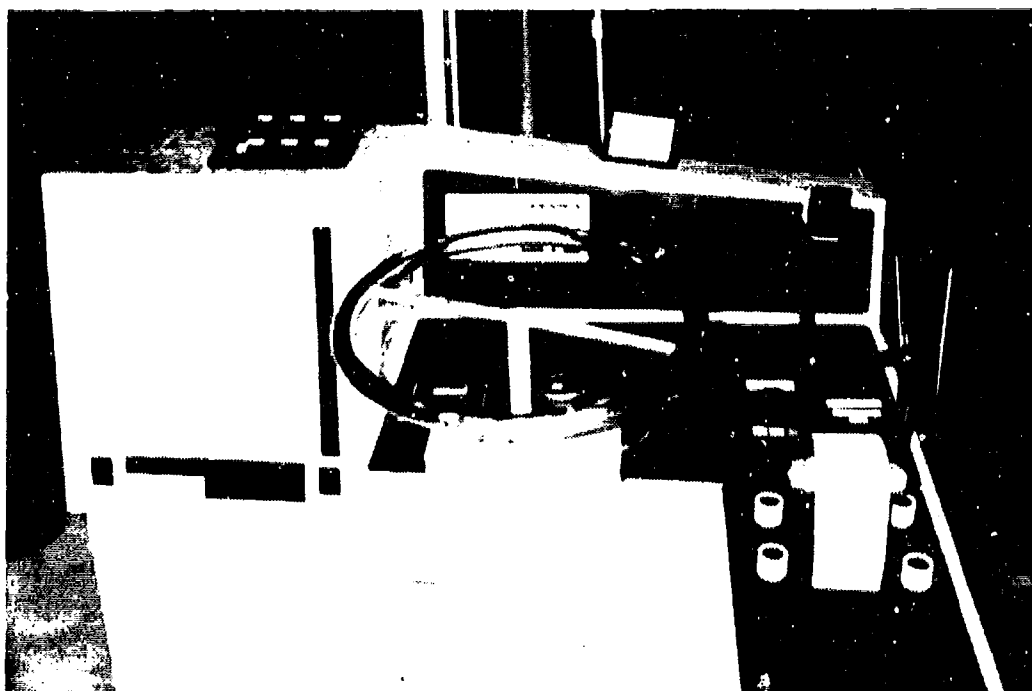


Figure II.1b. Proposed starboard steering station on open bridge.

Human Factors Assessment of USCG 47-ft MLB

addition, the fathometer, digital compass, and autopilot control are obstructed by hand microphone coiled cords (see Figures II.2a and II.2b). HFE guidelines recommend not placing one control or display behind another, which requires operators to reach around or shift equipment to see the display or manipulate the control.

- The autopilot control and fathometer displays accumulate internal moisture and compromise the view of the operator.
- The navigation light switch panel is located on the radar plotter screen enclosure.
- The wet compass is not located on the centerline.

Approach:

- The need for two steering mechanisms (both steering wheel and jog lever) on the starboard console is not clear. The proposed layout would eliminate the jog lever from the starboard console. The jog lever on the port console should serve as a backup steering mechanism on the open bridge.
- In place of two microphones, use a single microphone and selector switch to reduce the viewing obstruction to the control and displays. The switch should be located in close proximity to the microphone (see Figure II.1b).
- Relocate the hand microphone to the current jog lever position. This will allow the operator to easily reach and find the microphone.
- A retractable coiled cord arrangement may be used to eliminate the problem; a shorter cord is a less desirable option.
- Display units should be completely water and shockproof and should be filled with dry nitrogen to prevent fogging and internal corrosion.
- Relocate the wet compass to the centerline.
- The slope of the console controls and displays should be between 15° and 25°. This would also apply to the port steering station console controls and displays.
- The slope of the navigation light switch panel should be between 15° and 25° from the horizontal. The preferred slope is 18°. The slope of the panel can be varied according to the preference of the operators.
- Additionally a clear, impact-resistant cover or spray shield (hard plastic), hinged at the top of the console and covering the instrument panel, would protect the gauges from direct water contact. This shield need not form a watertight seal over the displays because the displays are required to be waterproof.

NAVAL BIODYNAMICS LABORATORY REPORT

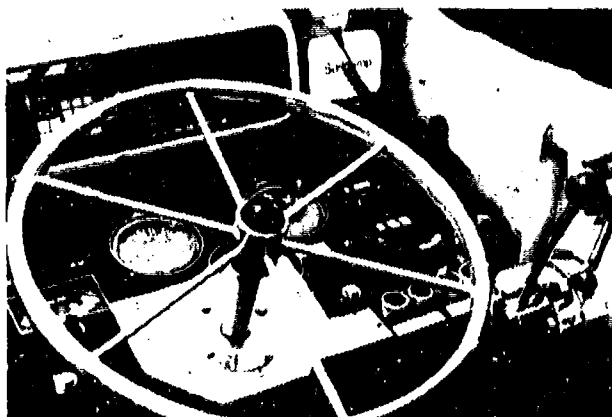


Figure II.2a. Current starboard steering station on open bridge.

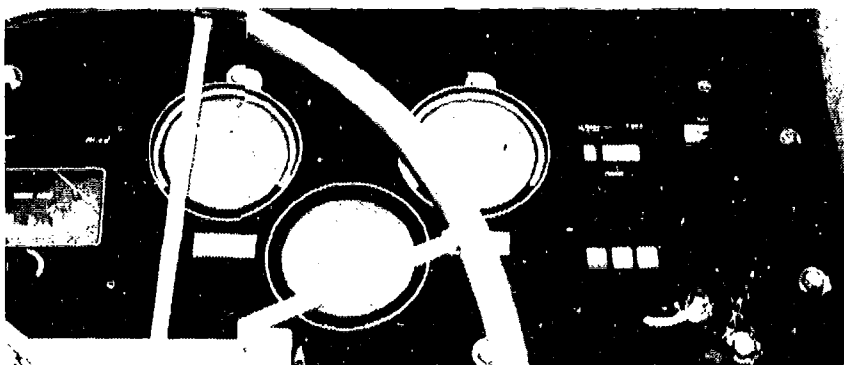


Figure II.2b. Current starboard steering station open bridge/dials.

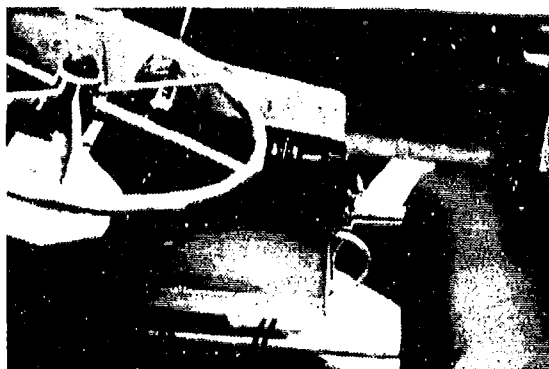


Figure II.2c. Starboard steering station.

4. OPEN BRIDGE: PORT CONSOLE

Figures II.3 and II.4 represent the current layout and design of the port console on the open bridge.

Problem:

- The throttle control is directly in front of the operator. In this position, there is a possibility of the operator inadvertently impacting the throttle control during rough water operations.
- The engine temperature and pressure indicators on the open bridge port console are not arranged in the same manner as the enclosed bridge indicators. In order to standardize the arrangement of the indicators, they should be grouped by function. This would minimize operator disorientation when moving from the open bridge to enclosed bridge or vice versa.
- The rudder angle indicator is placed starboard on the console directly above the jog lever. Controls which are placed above or below their respective displays are less confusing than those which are placed to the right or left of the display.
- An autopilot cutoff switch should be included at the port steering station. The port side operator(s) will be able to switch to manual operation without physically returning to the starboard steering station to disengage the autopilot.

Approach:

- The throttle control is placed port, outboard on the console. In this layout the likelihood of a crewmember bumping or inadvertently grabbing the throttle during rough water operations is considerably lessened (see enclosed bridge throttle configuration discussion below).
- The proposed console layout is recommended to avoid scattering controls and displays on the console without regard to functional associations (see Figure II.5).
- For example, the throttle control in its proposed position is on the same side as the engine indicators and the tachometers. Obviously, the throttle control is related to the indicators and the tachometers. Related functions should be arranged together so that their association is readily apparent to the operator. It is recommended that when a panel display is affected by a particular control, the display and control should be located near each other.
- Place an autopilot cutoff switch above the heading indicator on the port steering station console. A standard two-position toggle switch with a locking mechanism or protective cover to prevent inadvertent activation is recommended (see Figure II.6). The same type of mechanism is recommended for the alarm silence switch. The recommended minimum distance between the two toggle switches

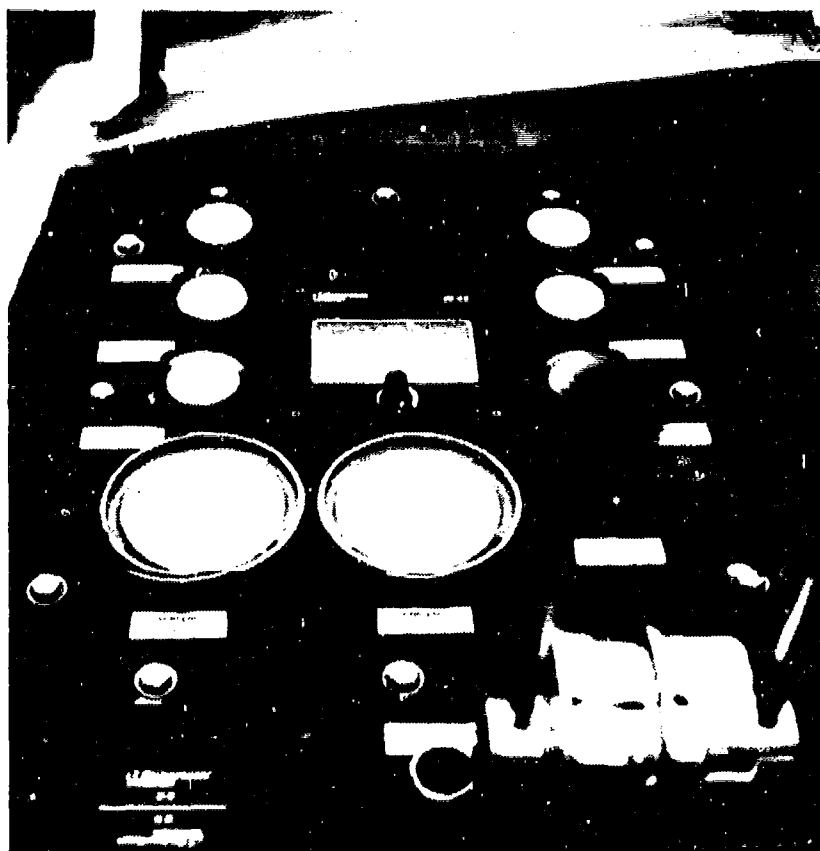


Figure II.3. Port steering station open bridge.

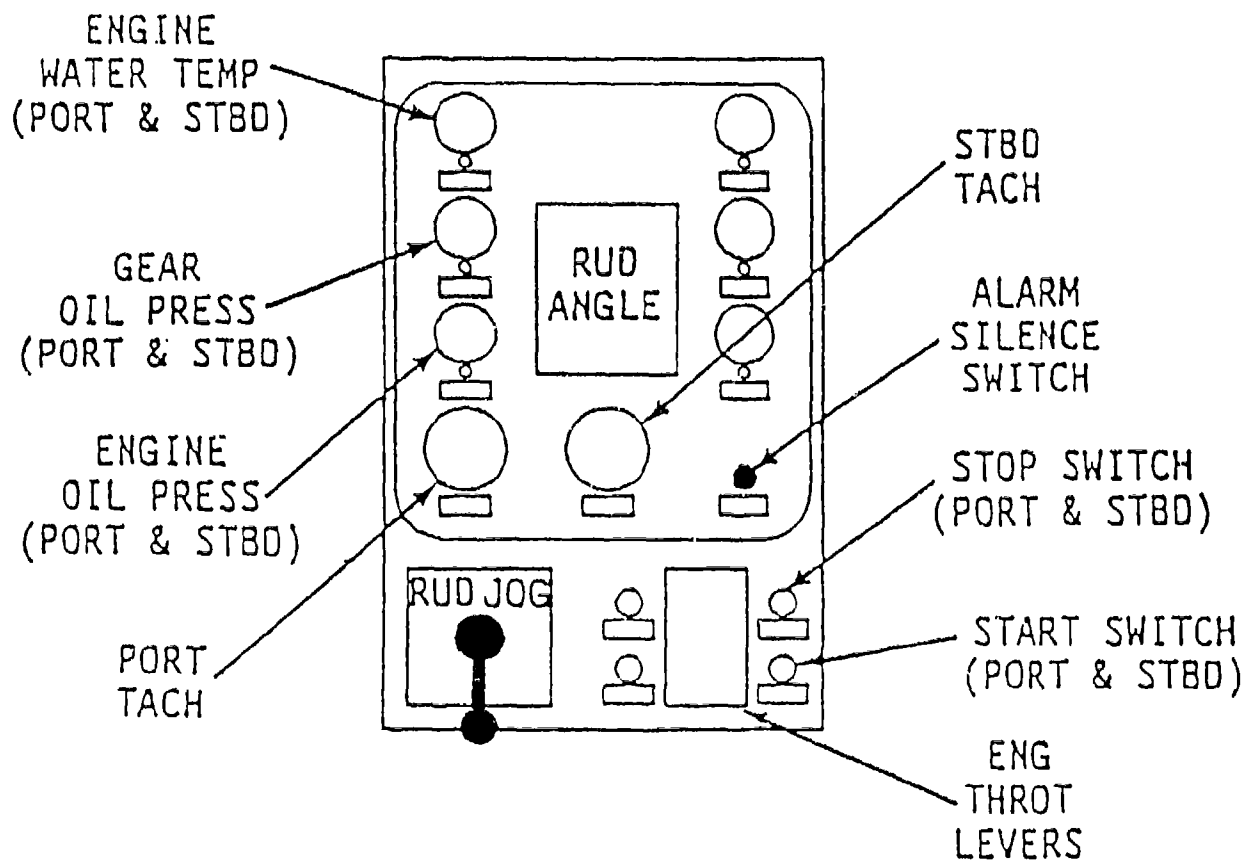


Figure II.4. Port steering station on open bridge.

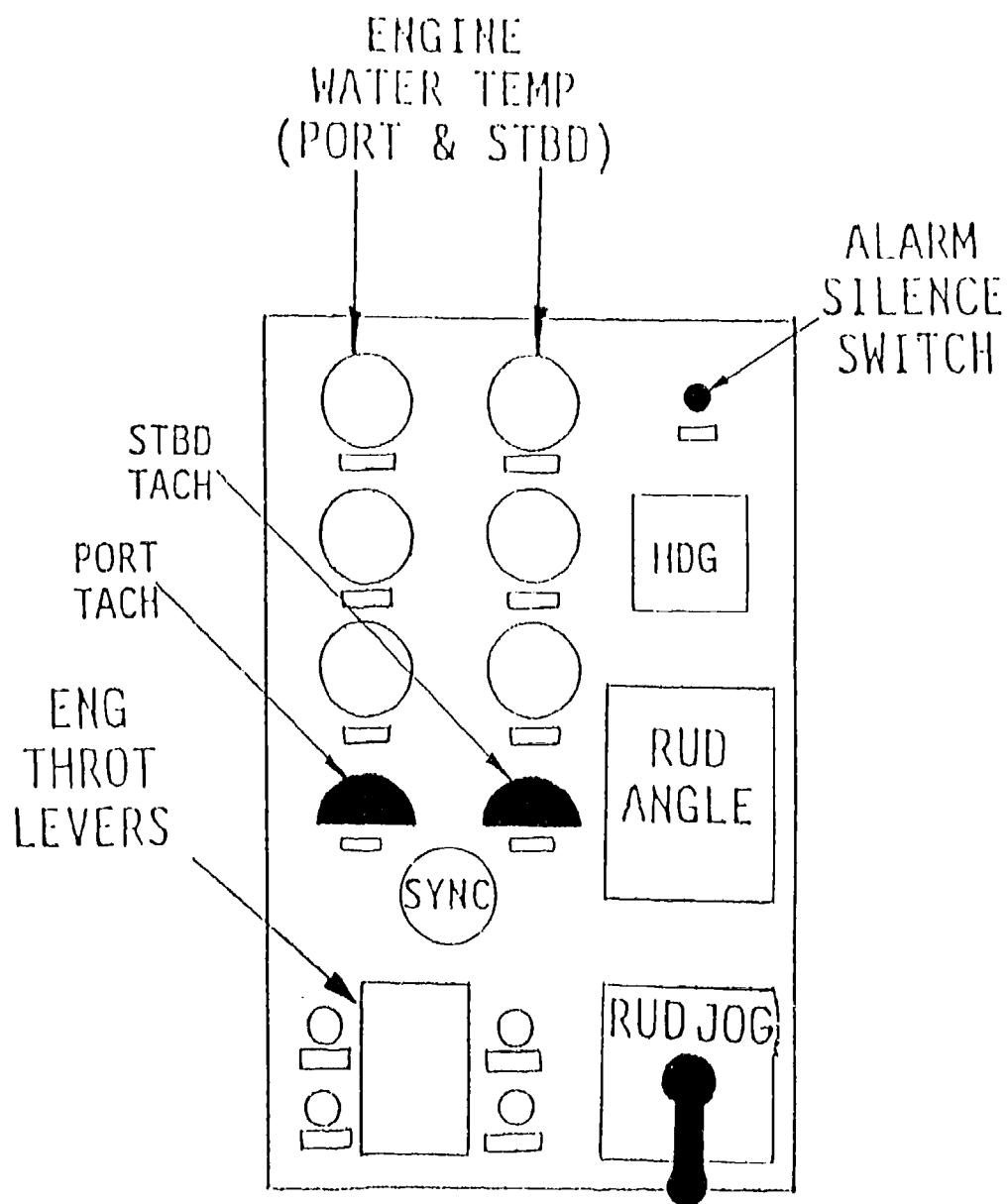


Figure II.5. Proposed port steering station on open bridge.

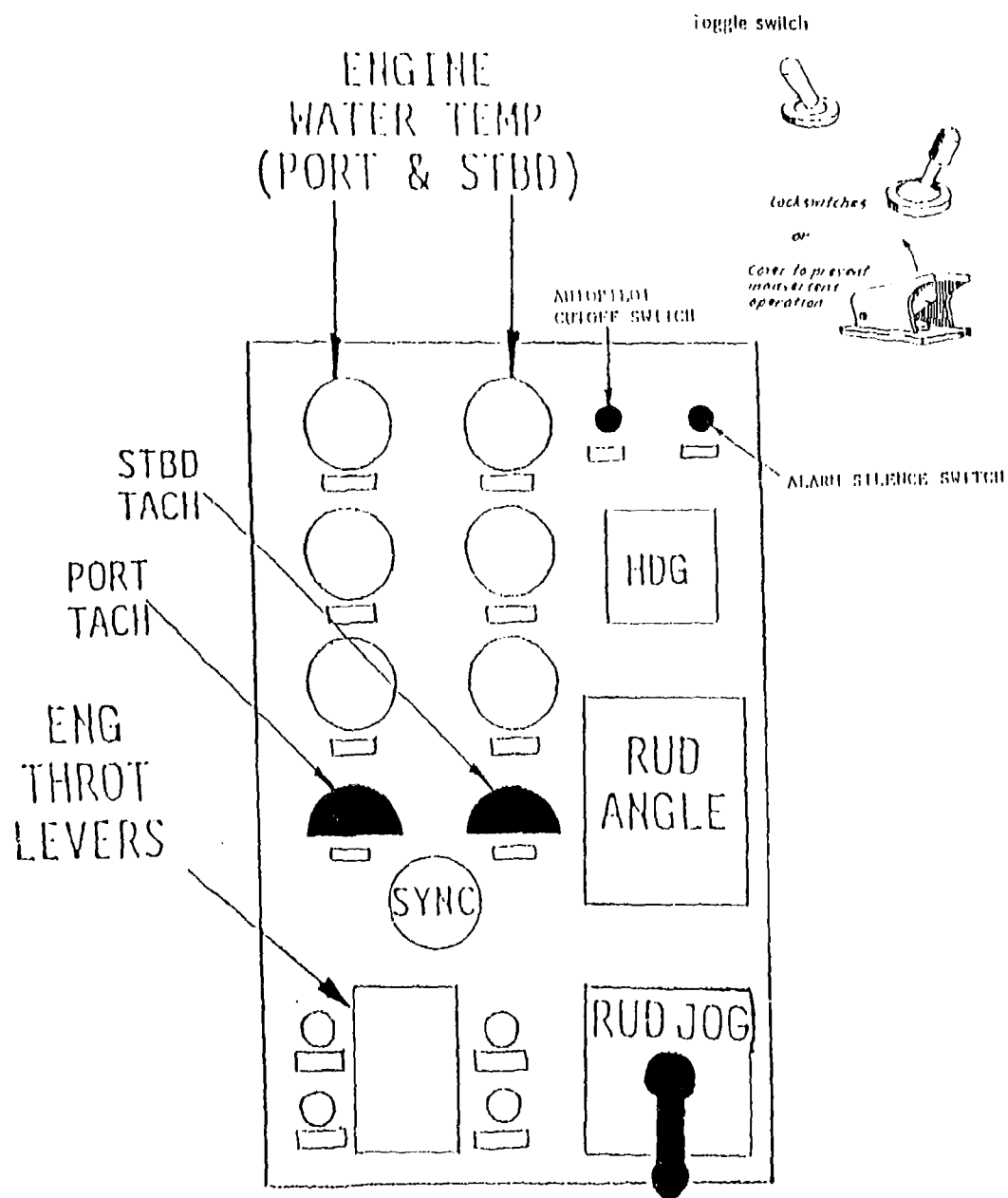


Figure II.6. Proposed autopilot cutoff switch on open bridge.

NAVAL BIODYNAMICS LABORATORY REPORT

is 1 inch; the optimal distance is 2 inches.

- A clear spray shield cover placed over the gauges would help the operator view the gauges (see discussion above).

5. CHAIRS

The open and enclosed bridge spaces include two operator chairs, one port and one starboard. The chairs are standard Turnbull type equipped with fore-aft and vertical adjustments, nominal seatpan backrest angle of 105°, contoured and cushioned backrest, and adjustable armrests. In addition, there are two "jump seats" located in the enclosed bridge for crewmembers.

Problem:

- The open bridge chair arrangement does not have foot rests; all the seats should be firmer, especially for rough seas, and seat restraints are marginally adequate in rough seas.

Approach:

- Footrests are required in order for crew personnel to brace themselves during rough sea conditions; footrests would increase the safety of the crewmembers in the open bridge as well as maintain basic foot-to-seat height relationship. In rough seas, the operator is forced to hold onto the chair or the steering station in a fixed position for long periods of time without rest. Providing footrests would help decrease overall fatigue. Figures II.7 and II.8 propose two approaches to providing footrests at the steering station. Figure II.7 illustrates a footrest bar extending from the chair to an optimal height and length. Footrests should maintain a desirable foot-to-seat height relationship from the pan of the chair (approximately 16-20 inches). Figure II.8 shows a side view of the starboard open bridge steering station with the proposed footrest located directly below the console or where the current access panel is located. The proposed footrests should be approximately 1/2 shoe length (4 to 6 inches). The proposed footrests would also apply to the open bridge port steering station.
- Chairs should be especially designed to maximize protection under g-loading and for comfort, ease of adjustments, and minimum weight. Chairs should be capable of rotating 360° and should have at least eight locking positions spaced equally throughout the rotation. The chairs should be capable of being swiveled freely when unlocked while supporting a load of 250 pounds.
- Firmer seatpan and backrest cushions are required to absorb violent whole body vibrations that otherwise would be transmitted to the operator when the MLB encounters rough seas. Transmission of vibration from the MLB to the head and/or limbs is dependent on the transmission of vibration through the seat, which in turn is

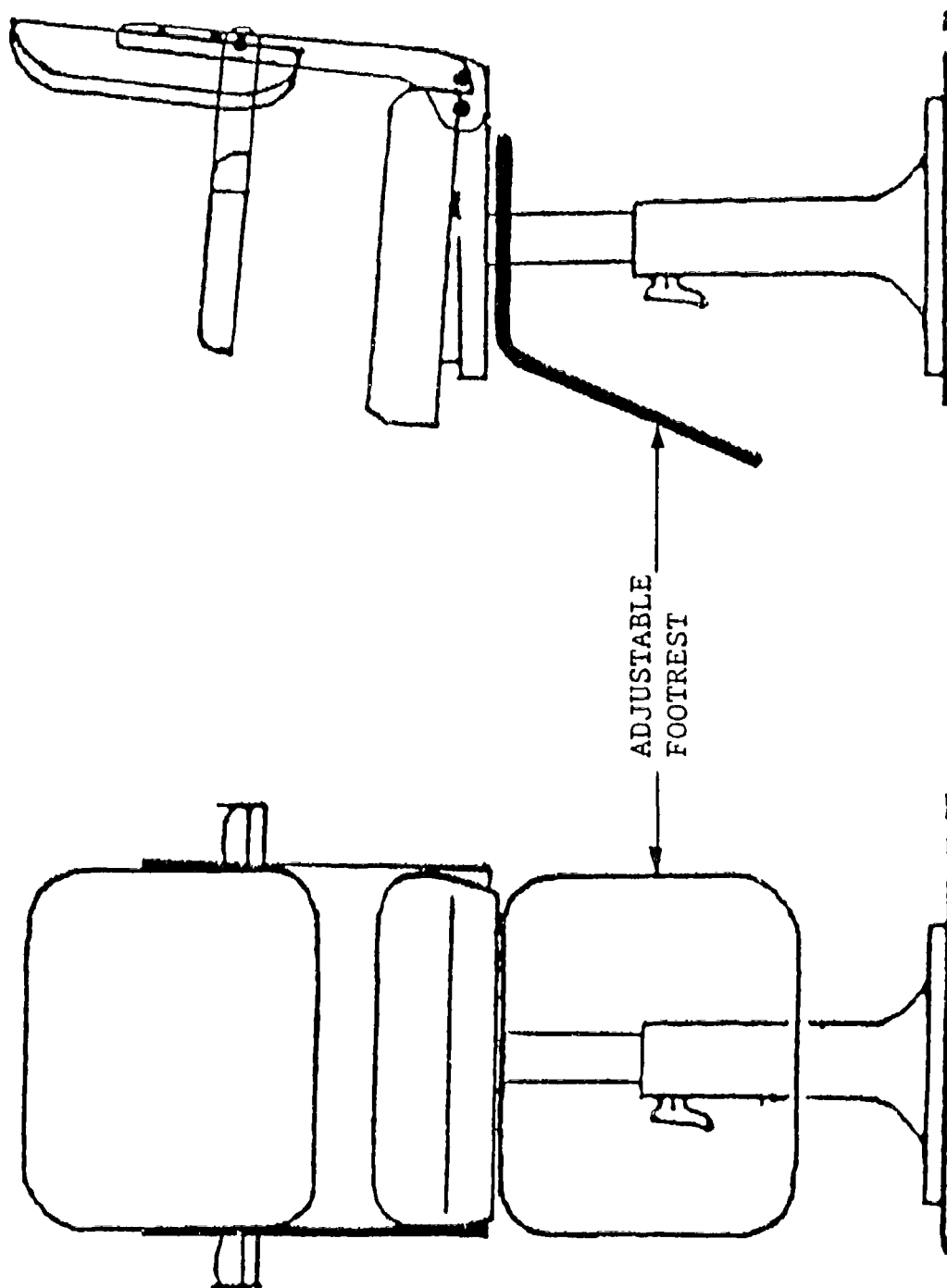


Figure II.7. Chair footrest.

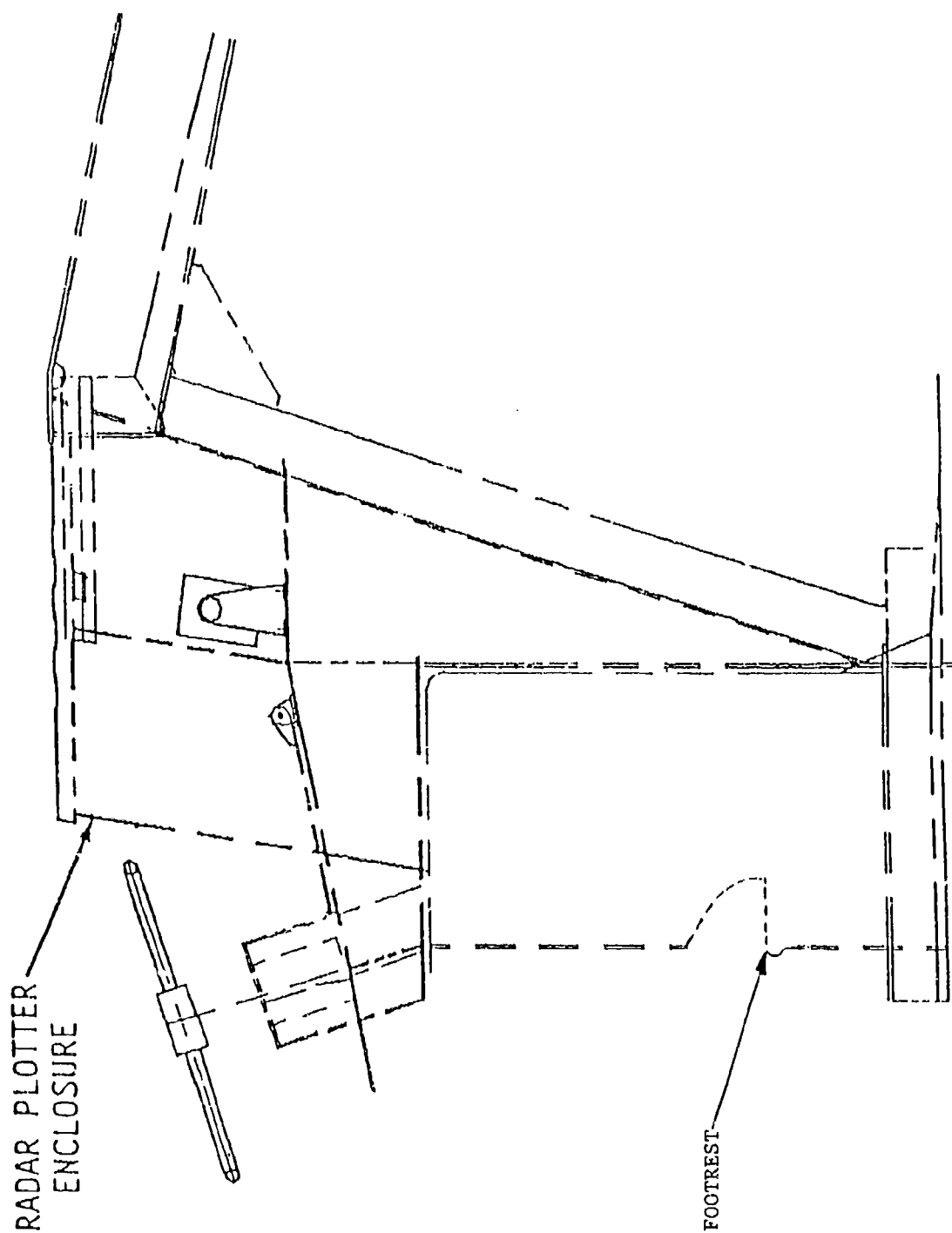


Figure II.8. Proposed footrest on open bridge starboard steering station.

affected by body characteristics. Seat padding should be kept to a minimum, but it should be resilient enough to keep the operator's body from contacting the seat bottom during rough seas. In addition, seat padding made of foam-type material should be adequately ventilated to prevent sweating. There are new air-suspension boat chairs on the market that are designed with lumbar support to reduce the shock and pounding of rough-water operations.

- Armrests can be designed to tilt inward to serve as a semi-restraint system for the chairs in both the open and closed bridges. The addition of a "wraparound" section to the backrest also helps secure the occupant against lateral movement/forces. Adjustment controls should always be designed and located so that the operator can use them easily, but the controls should not get in the way and cause crew injury (see Figure II.9).
- Seat restraints are required to ensure crew safety and stability during rough sea operations. It is recommended that a four-point seat restraint configuration be used. In this configuration two straps come over the shoulders and two over the lap and are inserted into a single locking mechanism over the lower abdomen of the operator (see Figure II.10). This seat restraint will not interfere with operational requirements of the crew.
- Remove the jump seats from the enclosed bridge.
- Install grab handles or handholds throughout the enclosed bridge space (bulkheads, overhead).

6. BENCH SEAT

The bench seat is located starboard and aft on the open bridge, below the mast platform. It provides seating for two crewmembers.

- Problem:**
- When the operator is steering the MLB from the enclosed bridge, the view of the open bridge and aft of the MLB is obstructed due to the bench seat.
- Approach:**
- Removing the bench seat would provide increased visibility of the open bridge and aft of the boat. Removal of the bench seat would require re-configuration of the aft door. One approach would be shortening the length of the door without compromising the access to the survivors compartment. As an alternative, the angle of the door and hatch can be modified. The top of the door would slant forward.

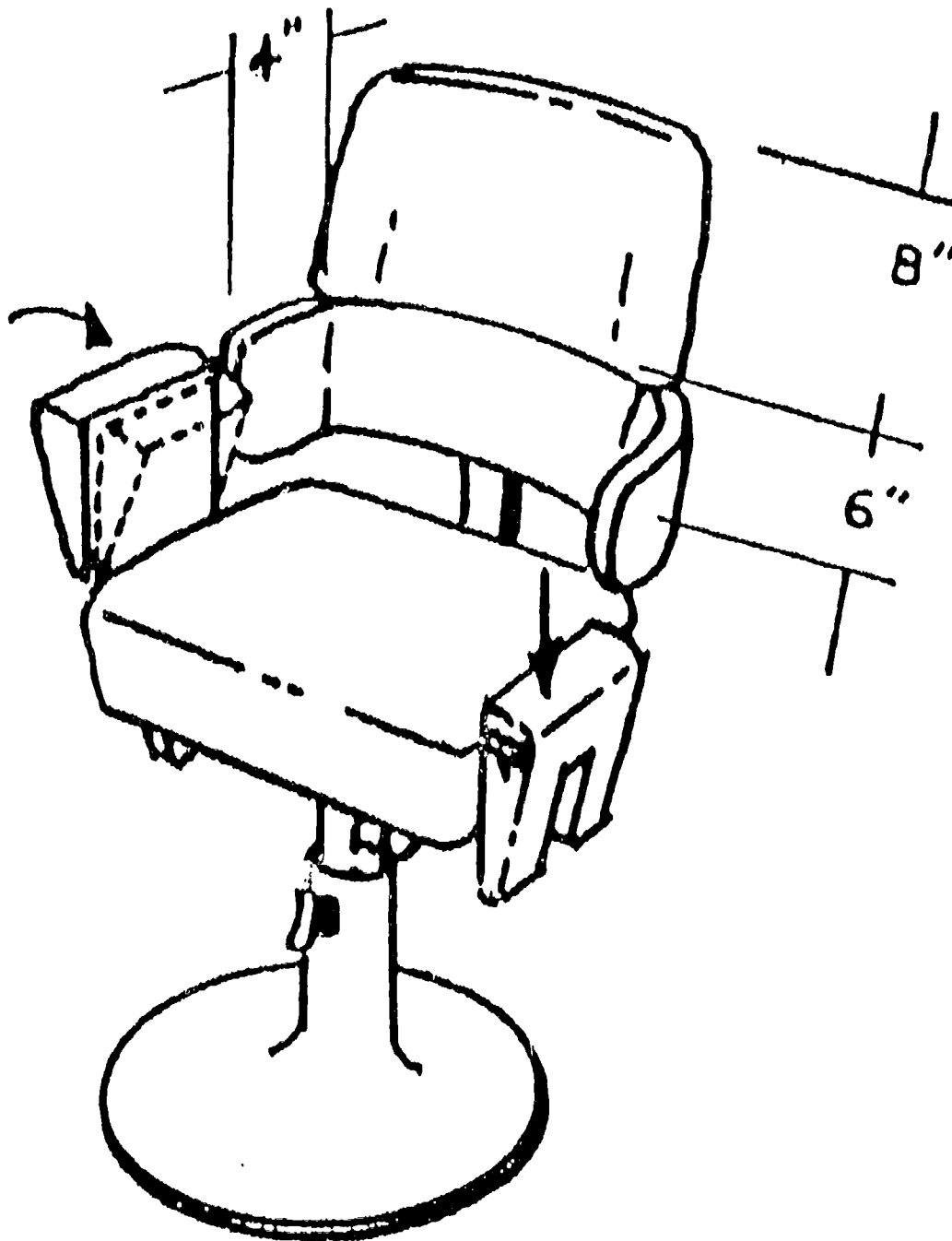


Figure II.9. Chair with "wraparound" backrest and adjustable armrest.



Figure II.10a. Front lateral view with four point seat restraint configuration.



Figure II.10b. Front lateral view with proposed seat restraint configuration.

7. ENCLOSED BRIDGE LAYOUT

A review of the current layout was conducted to:

- ▶ Ensure the best layout of controls and displays given the existing consoles.
- ▶ Identify alternative controls and display configurations that could perform the required functions and select the optimal configuration.
- ▶ Ensure that the controls and displays and their layout are in accordance with military standards and guidelines.

The appearance of the steering stations seems to indicate that the existing layout of controls and displays was based primarily on space considerations, placing equipment where it would fit (see Figure II.11). A more organized arrangement is possible. However, the current layout due to the constraints of the boat may not follow optimal human factors engineering fundamental guidelines, but should be adequate.

Primary steering control is exercised from the port forward seat. The port operator has a clear view of the port dashboard indicators/gauges. The starboard station is used primarily for navigation and engine instruments monitoring.

Problem:

- The center console in the enclosed bridge poses crew habitability and minor hazard problems (e.g., limited knee clearance); port and starboard electrical panels occupy the limited workspace of the enclosed bridge; shore tie installation requires relocation; the battle lantern and hydraulic reservoir pose minor crew hazards; workspace is limited with crew wearing either light clothing or protective clothing; fold-out chart table is dysfunctional.

Approach:

In order to maintain and enhance the use of the enclosed bridge steering stations and improve crew workspace, the following recommendations are proposed:

- Relocate controls and displays from the center console to the dashboard or overhead. The center console would be eliminated from the current enclosed bridge configuration. In this configuration the throttle control is mounted on a centerline panel, allowing both operators free movement to enter and exit their chairs (see Figure II.12). The Loran-C may be relocated to the aft side of the centerline panel and accessible to both operators. Another possible location for the Loran-C would be in a position under the proposed centerline mount.
- Relocate outboard port and starboard electrical panels (see Figures II.13 and II.14) to a watertight compartment accessible to the engineering crew. It is recommended that the panels be relocated

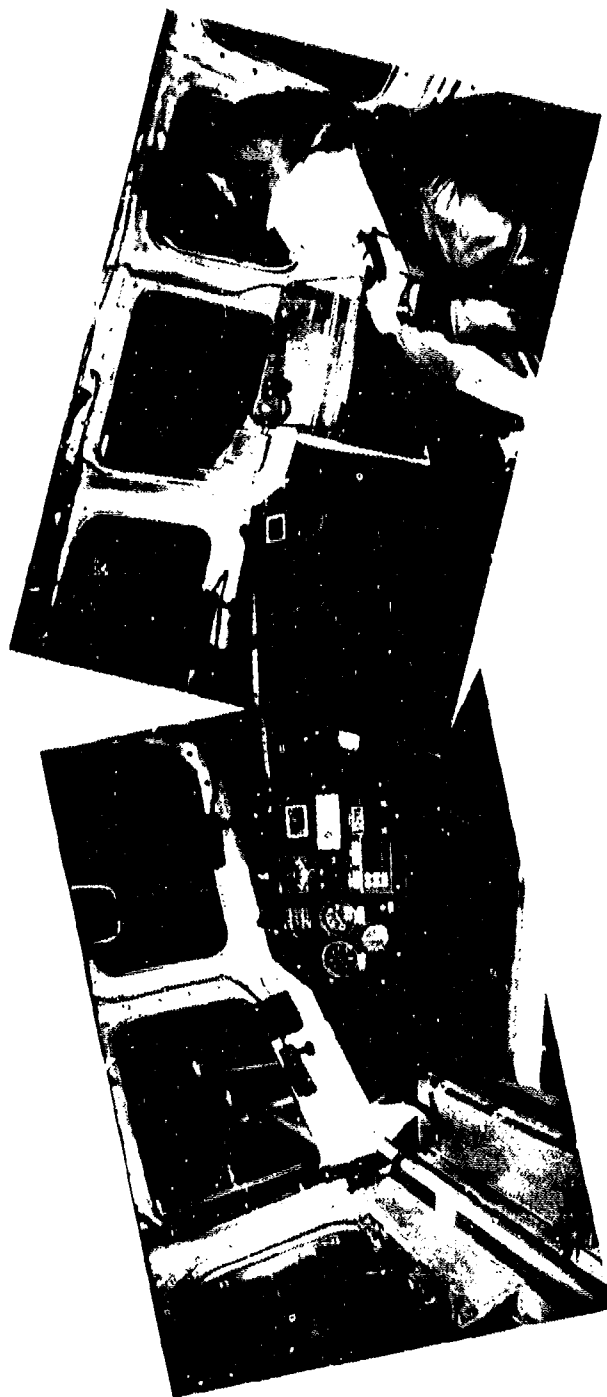


Figure II.11. Wide angle view of enclosed bridge.

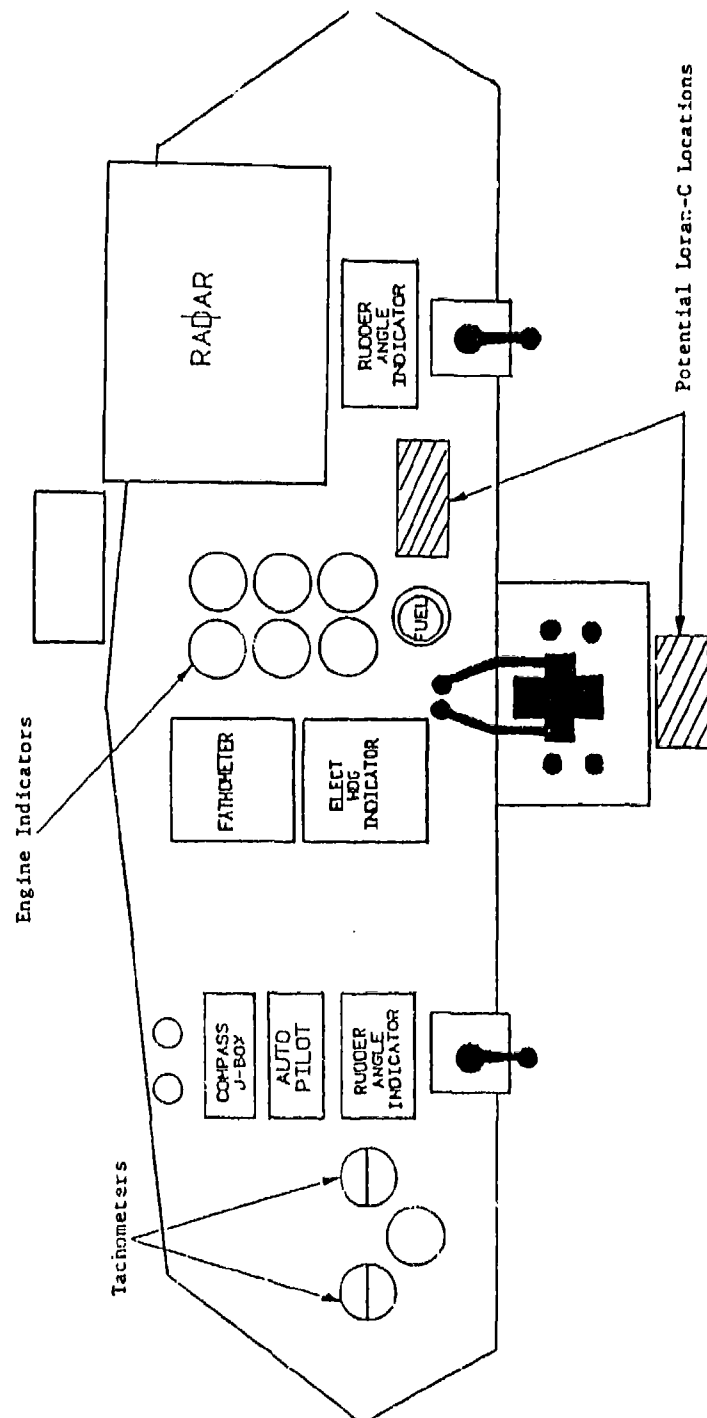


Figure II.12. Proposed layout of enclosed bridge with jog levers.

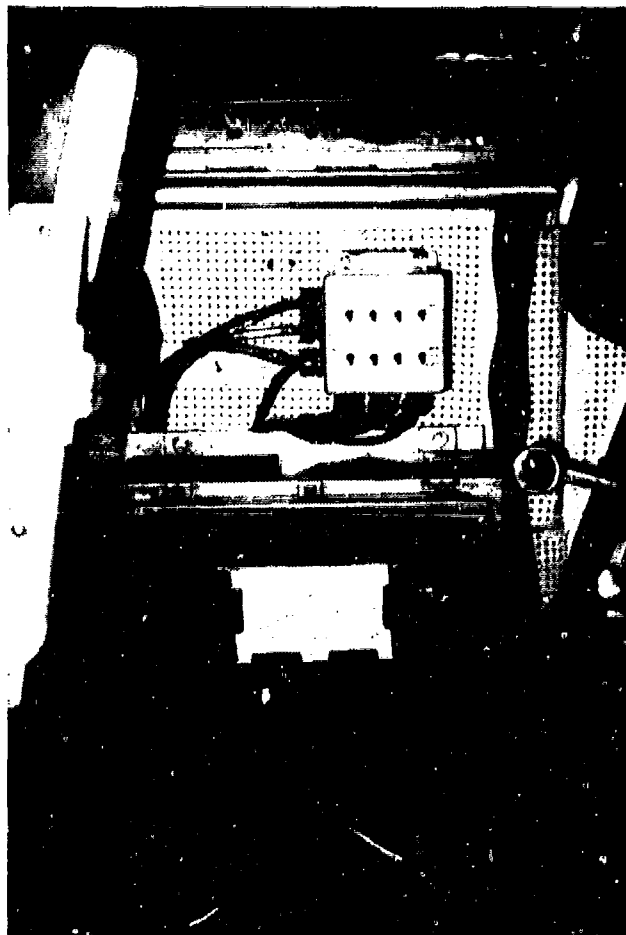


Figure II.13. 12 volt DC panel starboard bulkhead of enclosed bridge and starboard jump seat.

in the auxiliary engineering compartment or the survivors compartment of the MLB.

- Relocate the shore tie closer to the beam of the boat. This arrangement would eliminate the need for the port bulkhead protrusion into the enclosed bridge (see Figure II.14) and would increase crew workspace (habitability).



Figure II.14a. Portside of the enclosed bridge ladder and jump seat.

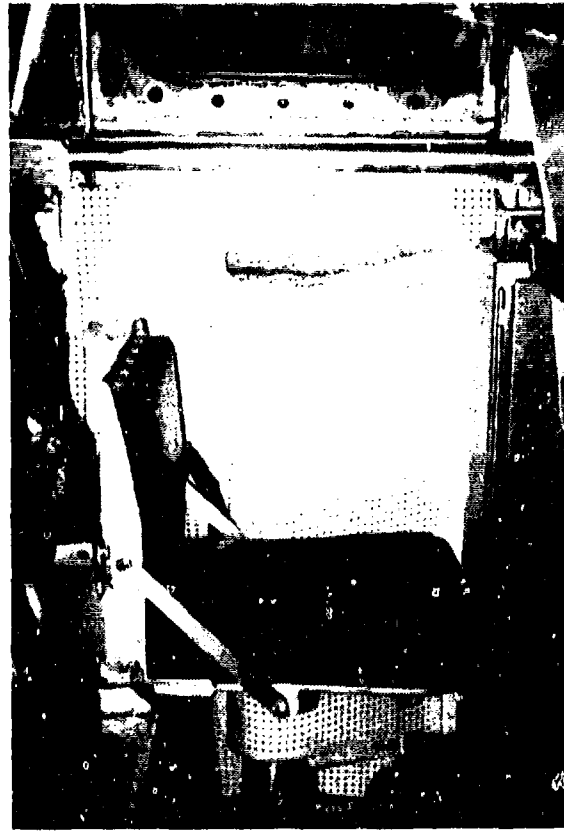


Figure II.14b. Portside jump seat and shore tie.

- Replace the heating ventilation and air conditioning unit with a more compact unit (see discussion below).
- Relocate the battle lantern that is located on the aft bulkhead of the enclosed bridge (see Figure II.15). It is located underneath the port railing of the ladder and poses a minor handling hazard to crew climbing the ladder. The current hydraulic fluid reservoir location is an alternate location (see hydraulic fluid reservoir discussion below).

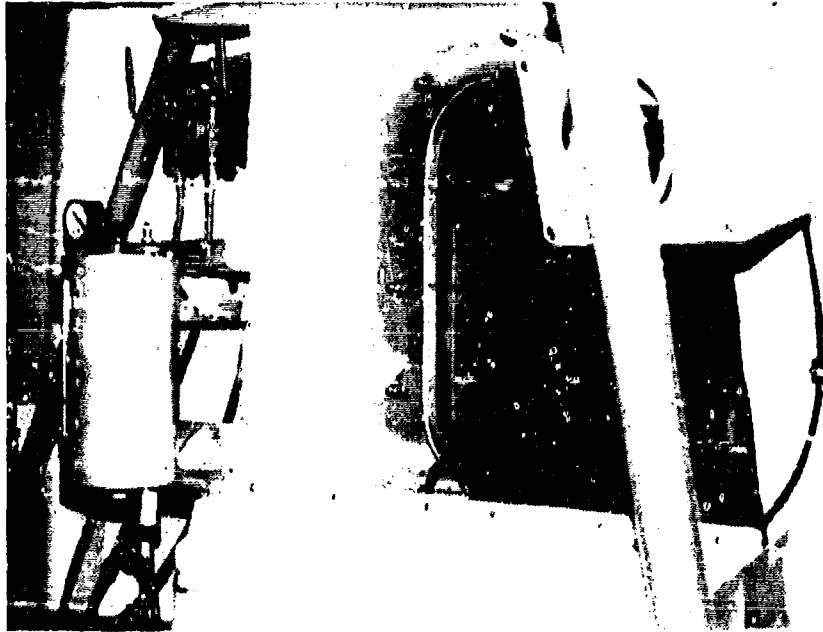


Figure II.15. Aft window of the enclosed bridge battle lantern and hydraulic fluid reservoir.

- Figure II.16 illustrates a layout that utilizes two sets of jog levers and throttles, increasing the ability to maneuver the boat from the enclosed bridge. In this configuration the primary steering station is located starboard and the navigation station is located port.
- Engine indicators are located in the centerline of the dashboard, providing unobstructed visibility of the indicators. The radar screen is located starboard.
- An autopilot cutoff switch is located near the center of the dashboard. Engine start/stop switches and fast idle clutch release handles are located near the centerline of the dashboard.
- All throttle controls should be designed to include throttle lock-out control or control cover to safeguard against inadvertent control manipulation. Controls without lock-outs are engaged at all times and inadvertent operation could be dangerous in close-in maneuvering, as the operator may not be able to regain control of the boat from unexpected throttle movement.
- A chart table should be located in the enclosed bridge. With the removal of the chair-mounted jog levers, the current chart table location may be adequate.

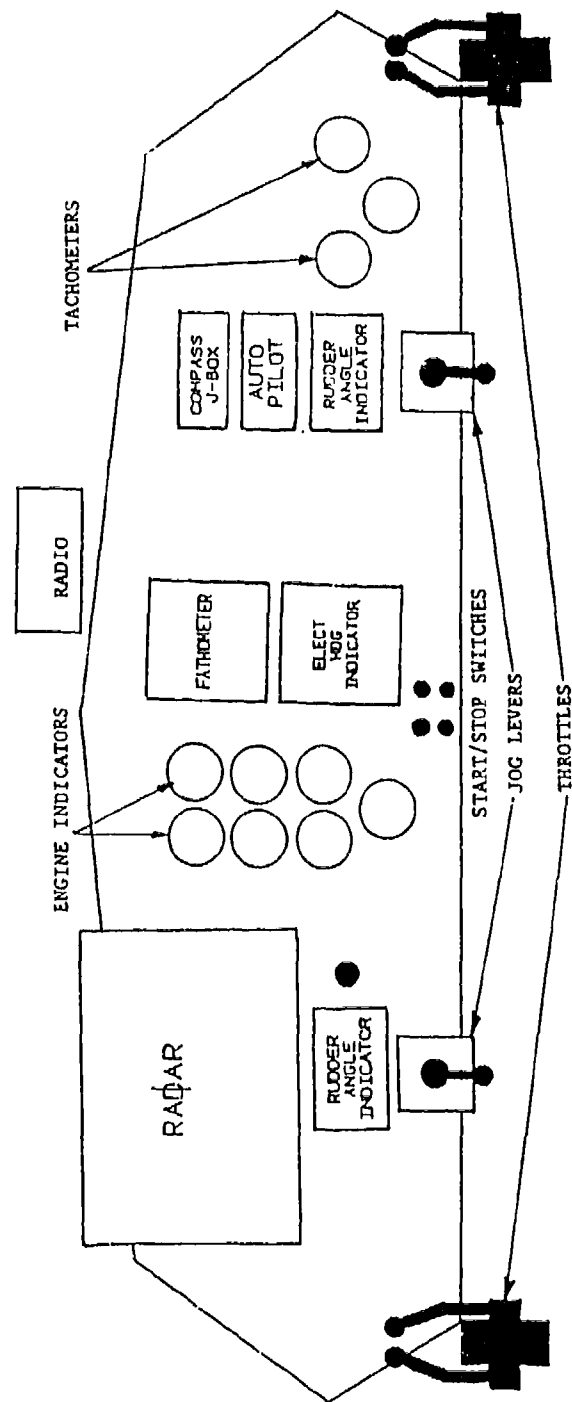


Figure II.16. Proposed enclosed bridge with two sets of jog levers and throttles.

Human Factors Assessment of USCG 47-ft MLB

- The overhead of the enclosed bridge is available for the placement of control devices (e.g., switches). Numerous features that present hazards to crew are present throughout most vessels. These should be reviewed carefully during concept design so that they do not reoccur by default (e.g., previous design practices which are assumed to be acceptable). It is recommended that controls that are placed in the overhead space should not have sharp corners and/or edges; should not be too close to handholds, cables, vents, etc.; and should not have excessive cables dangling into the workspace. Navigation light switch panel, loud hailer, VHF-FM radio, toggle switches, and infrequently used instruments may be considered for relocation to the enclosed bridge overhead.

8. CONTROLS

The jog lever controls have approximately 30° movement right and left. Control input for a turn remains "in" when control is neutralized until canceled by appropriate control input. The coxswain's control is attached to the end of the left arm of the chair; on the engineer's chair the control is attached to the right arm. In both cases the jog lever is oriented in the vertical plane, and the jog lever moves laterally.

On the open bridge there are two jog lever controls, but they are oriented on the horizontal plane. Push the lever right and the boat turns right; push it to the left, the boat turns left.

One HFE issue is whether the lever input characteristics allow the operator to perform the necessary movements, thereby adequately controlling the boat during critical maneuvers.

Another issue is whether equal steering performance, especially during tight, precise movements, will be obtained across the open and enclosed bridge configurations. Steering performance may not be equivalent for the two steering stations.

The location and shape of the jog lever box presents a safety and functional discrepancy. The sharp edges of the lever mechanism, located at the end of the outboard chair arms, are potentially hazardous to the operator. During rough seas, an operator's hands or arms could be injured if they forcibly strike the lever.

When the folding chart table is in the open position the starboard jog lever is obstructed and its use is compromised in some chair positions.

The arrangement of the jog levers in both open and enclosed bridges should be consistent in principle and operation.

Approach:

- Relocate the enclosed bridge jog levers from the operator chairs to the dashboard/console in the horizontal position (see Figure II.17). Operators are usually in a standing position when conducting mooring and other critical maneuvers. Moreover, the relocation of the levers will allow the operators to operate the lever controls comfortably (in both sitting and standing positions). This design incorporates the proposed centerline throttle position. The jog

NAVAL BIODYNAMICS LABORATORY REPORT

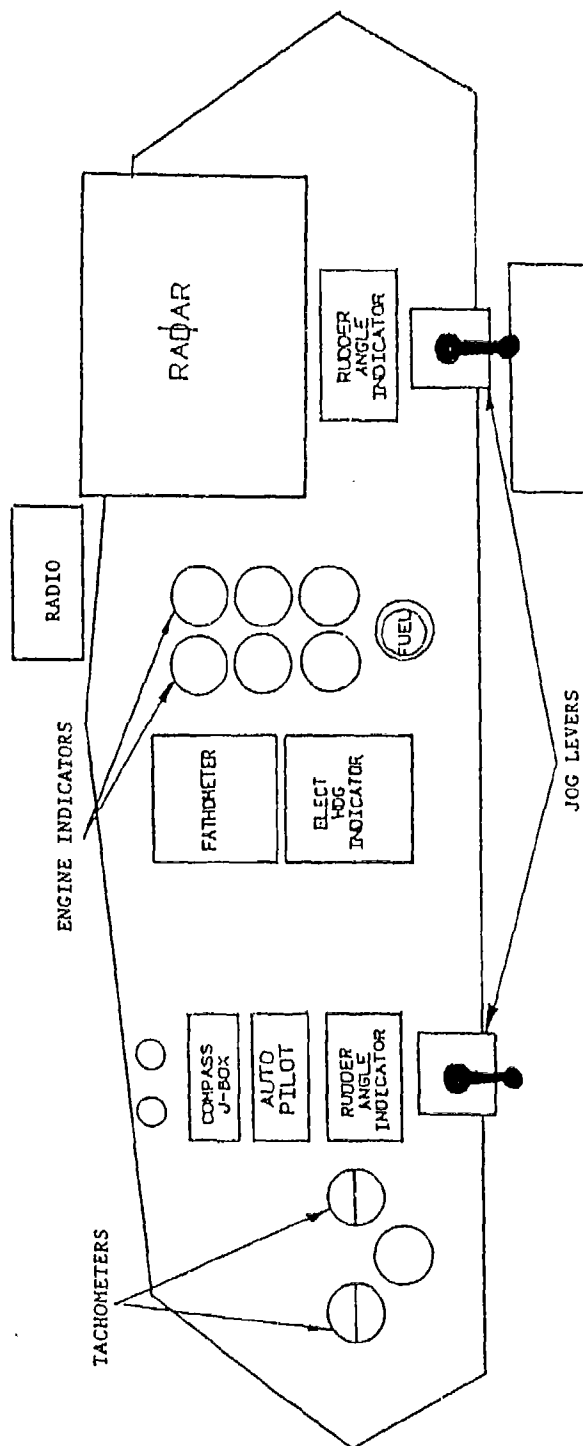


Figure II.17. Proposed enclosed bridge layout.

Human Factors Assessment of USCG 47-ft MLB

levers should be installed in a horizontal position, not angled with the slope of the dashboard.

9. DISPLAYS

Dials and gauges are used to provide quantitative information. Analog dials and gauges also provide information in the form of advance warning, rate of change, etc., due to the pointer position and motion acting as an additional quantitative cue to what is happening.

- Problem:**
- Radar plotter screen: The radar plotter is located between the port and starboard dashboards. The radar plotter is visible and accessible to both operator positions (see Figure II.18).
- Approach:**
- Relocate the radar plotter screen to a higher position on the dashboard (see Figure II.19). In addition, the angle/inclination of the screen should approximate 105°. The radar plotter keyboard functions as a duplicate of the controls on the radar plotter. The keyboard is not essential to the operator of the screen and should be eliminated.
 - In the proposed configuration, additional dashboard space is available for the placement of center line console controls and displays (e.g., Loran-C, spotlight switches, etc.).
 - Engine water temperature, engine oil pressure, gear oil pressure, and fuel tank indicators: The enclosed bridge dashboard follows fundamental guidelines of display layout. It groups these gauges together because they relate to a common system and rearranges them so that they are in the same general area of the dashboard.
- Problem:**
- As noted above, the gauges on the open bridge console are not arranged in the same manner as those within the enclosed bridge.
- Approach:**
- Arrange the gauges in a similar manner in both open and enclosed bridges (see Figures II.5 and II.12).
 - Wet compass in the enclosed bridge: This compass is attached to the overhead above the port operator's position (see Figure II.20). Normally, to steer a heading, one lines up the compass lubber line with the desired course degree heading of the compass. The helmsman and lubber line are normally in parallel alignment with the boat's longitudinal axis.
 - It is recommended that the wet compass be retained in the enclosed bridge and located on the dashboard in line with, or directly above, the main steering position.
 - An analogue type of dial provides the operator with variations in heading. The digital type of readout only provides a "static" heading reading.

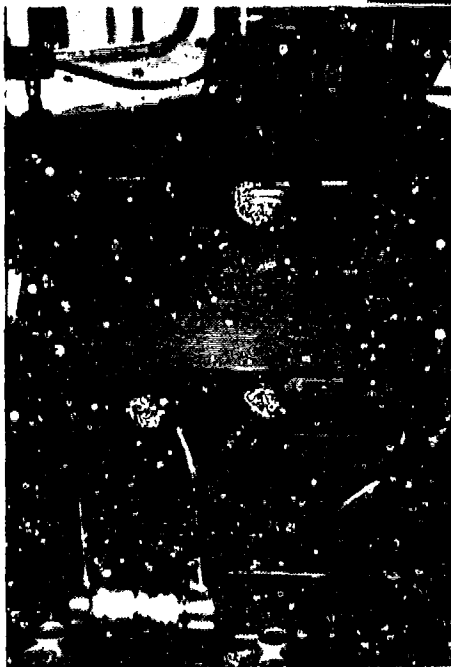


Figure II.18a. Radar plotter screen.

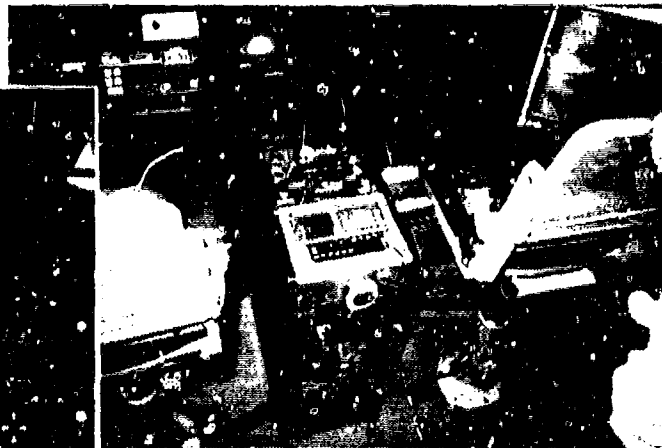


Figure II.18b. Centerline console.

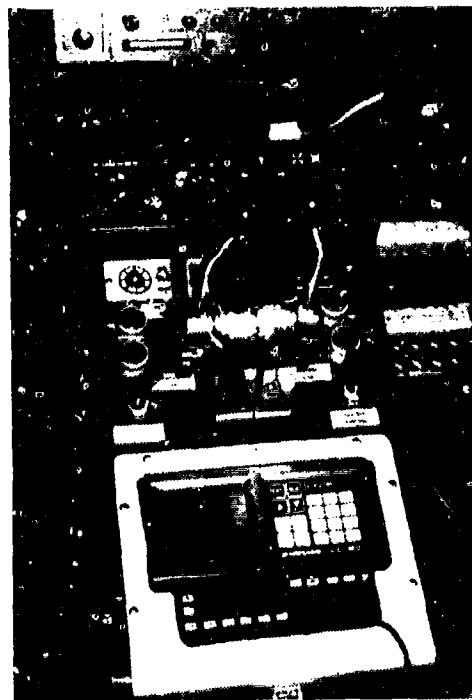


Figure II.18c. Throttle control, Loran C and other controls.

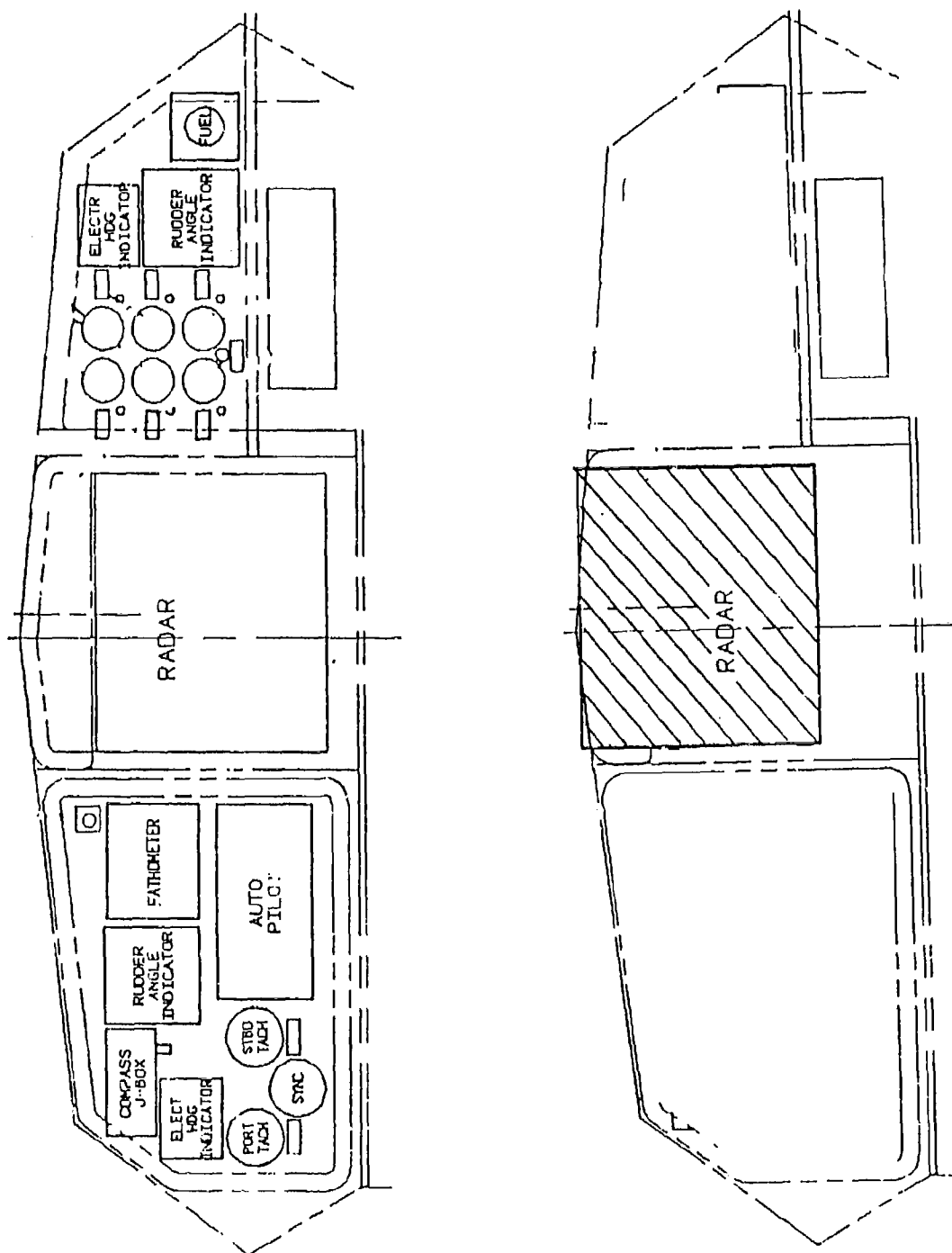


Figure II.19. Proposed relocation of radar plotter.

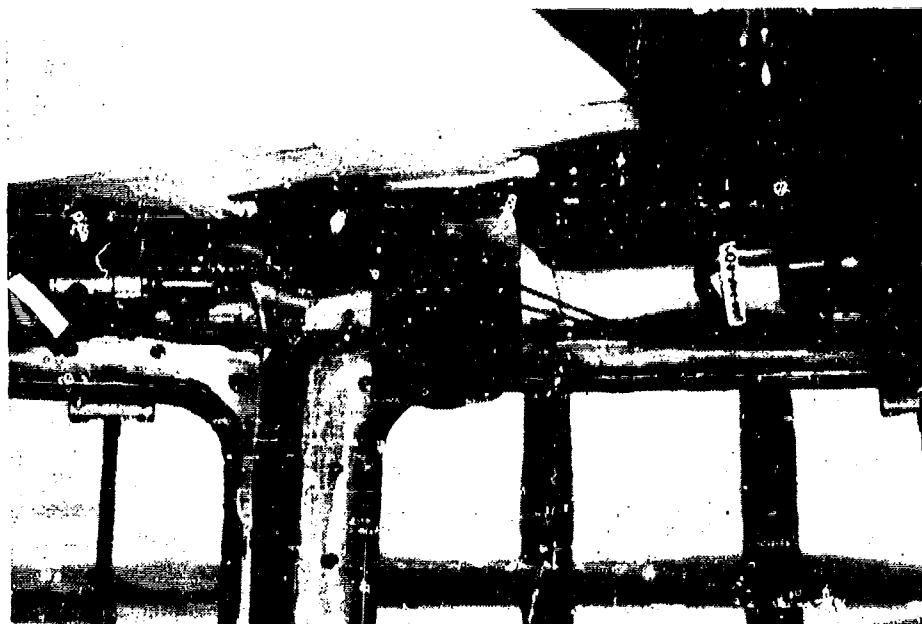


Figure II.20. Wet compass and window wiper controls.

- A heading indicator is located on the starboard steering station on the open bridge. However, a rearrangement of the port steering station displays could accommodate a heading indicator. Figure II.6 illustrates a proposed configuration of the steering station including the heading indicator.
- If the electronic heading and the rudder angle indicators are required at both steering stations, then they should be arranged the same way in both port and starboard locations (heading indicator placed above the rudder angle indicator arrangement, as in Figures II.12 and II.16).
- Compass J-box: The compass J-box is located on the port side of the dashboard above the autopilot. The function of the unit is to act as a junction box that operates four digital compass repeaters (total) located on the two bridges. The J-box controls include a selector knob with four selection indicators that control one to four compass repeaters and an on-off switch. Its function is to activate the digital compass during operations. In most operations the crew will activate all heading indicators.

Human Factors Assessment of USCG 47-ft MLB

- Problem:**
- The frequency of use and function of the J-box unit does not justify its location on the dashboard.
- Approach:**
- Relocate the compass J-box from the dashboard to a position with other on-off switches that are located in the overhead or on the proposed center mount.
 - Hydraulic fluid reservoir: This instrument is located on the aft bulkhead of the enclosed bridge, starboard of the aft window (see Figure II.15).
- Problem:**
- The hydraulic fluid reservoir poses a hazard to the crew.
- Approach:**
- Relocate the hydraulic fluid reservoir from the enclosed bridge to another location (auxiliary engineering or survivors compartment).
 - Tachometers and syncrometer: These gauge displays are located on the port side of the enclosed bridge. The port and starboard engine tachometers are located on the dashboard directly in front of the port steering station. The tachometers and syncrometer are 4 5/8 inches in diameter. As shown in Figure II.11, both tachometers are arranged side-by-side with the syncrometer located directly below them. In Figure II.21, both round (or half round) and linear or rectangular formats are illustrated. It has not been shown that either format results in any difference in readout effectiveness. However, several rectangular gauges can be placed more closely together than round dials. This, of course, depends on the particular instrument package shape behind the panel. The port console of the open bridge is illustrated in Figure II.5 with the half-round tachometer configuration.
 - If the round dials are preferred by most operators, smaller diameter dials should be used to improve space efficiency without compromising boat operation. Smaller dials/gauges are recommended in both open and enclosed bridges. Rectangularly shaped gauges may be used as a substitute for the round dials.

10. WINDOWS

The most important functional characteristic of windows is unobstructed operator visibility. The size, shape, and translucence of the windows allow minimal obstruction of the operator's exterior view as a result of overhead structure, reflections on either the interior or the exterior surface of the window glass, optical distortion in the glass itself, or the inability to keep the windows clear of rain, sea spray, fog, mist, snow or ice. The operator and crew are able to see sea traffic features (other boats/vessels, buoys, etc.) in all directions either directly or by means of appropriately positioning the boat.

NAVAL BIODYNAMICS LABORATORY REPORT

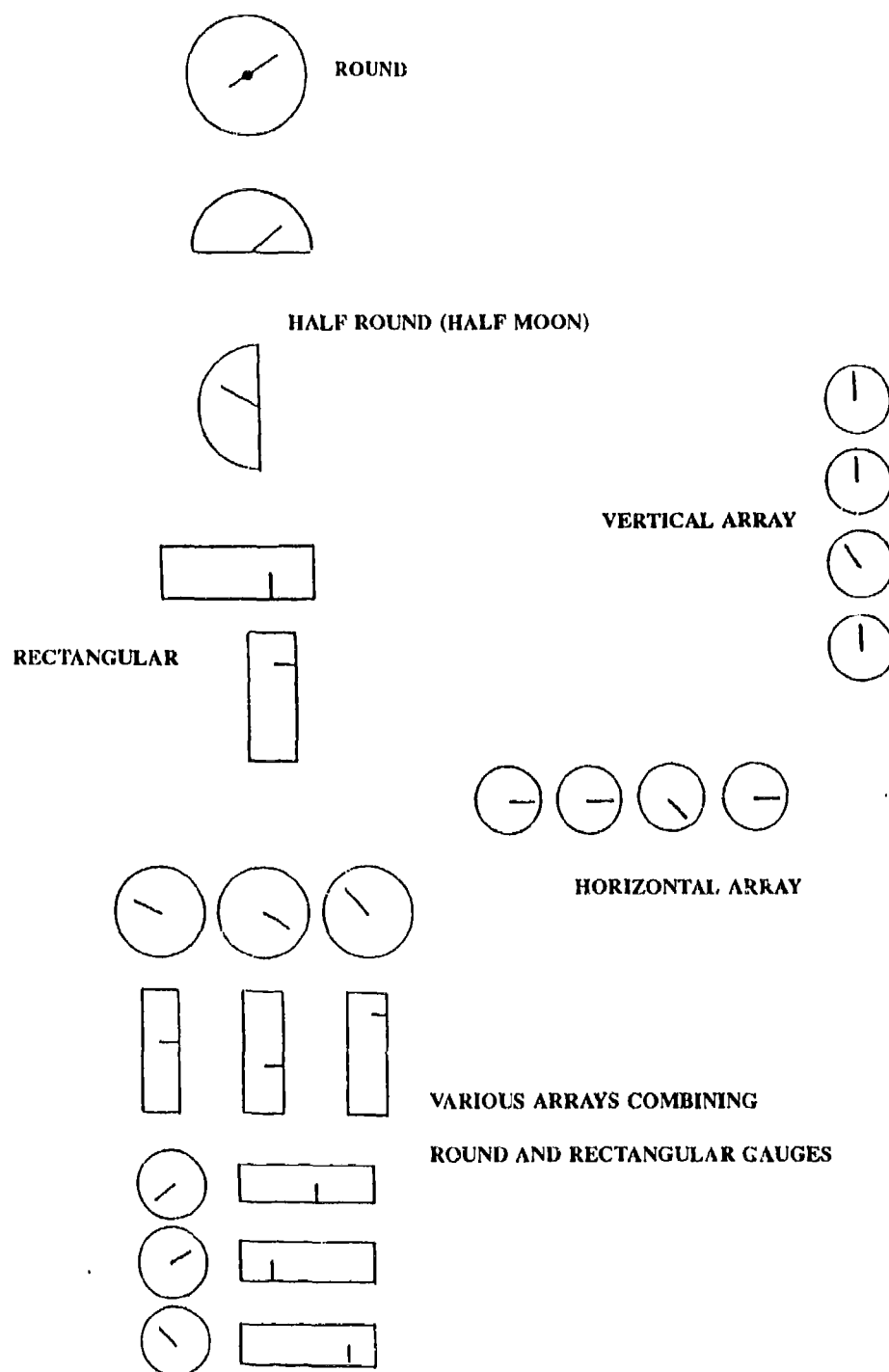


Figure II.21. Gauge formats.

Human Factors Assessment of USCG 47-ft MLB

The forward windows have windshield wipers. Windshield cleaning fluid is fed from a plastic tank to nozzles located at the bottom of each window.

The window blower/heater switch panel is mounted on the overhead at the centerline and between the two forward seats (see Figure II.22). The window washer button is located on the dashboard in front of the portside chair. The window wiper control panel is located directly aft of the radar plotter keyboard.

Problem:

- The window cleaning/washing system is marginally adequate. The dispersing nozzle is located at the bottom of the windows. Due to a restricted spray pattern, the cleaning fluid is not dispersed adequately over the window surface.
- The controls for the windshield wipers, blowers/heaters, and washers are in different locations in the EB. The window blowers/heaters control switches are located in the overhead; the window washer on the dashboard; and the blower controls on each window. These functionally related controls should be relocated to the same area on the dashboard or to an overhead area.
- The two windows that have top hinge mechanisms open accidentally during rough seas. There is a plate welded between frames in the window opening. This plate, which is approximately 3 inches high, creates a pinch point when the window is operated. Additionally, this plate makes the opening and closing of the windows more difficult and potentially hazardous.

Approach:

- Relocate the window cleaning nozzles to the top of the windows, allowing for top-down and inboard-to-outboard cleaning fluid dispersal. The window cleaning fluid would have a wider dispersal area if the nozzles were mounted and aimed from the top of the forward windows.
- Group windshield cleaning controls together on the forward dashboard or in the overhead.
- To increase the visibility of the operator an additional window in the hatch door to the open bridge may be installed. As an alternative, the current window can be enlarged. In both cases the operator would have a wider view of the open bridge and aft of the boat, particularly during towing operations.
- Provide a locking mechanism on the hinged windows that is shock and vibration resistant. Remove the plate covering the lower window frame. Redesign the window latching mechanism to ease the operation of the window and label the correct movement of the latch handle to open and close the window.

NAVAL BIODYNAMICS LABORATORY REPORT

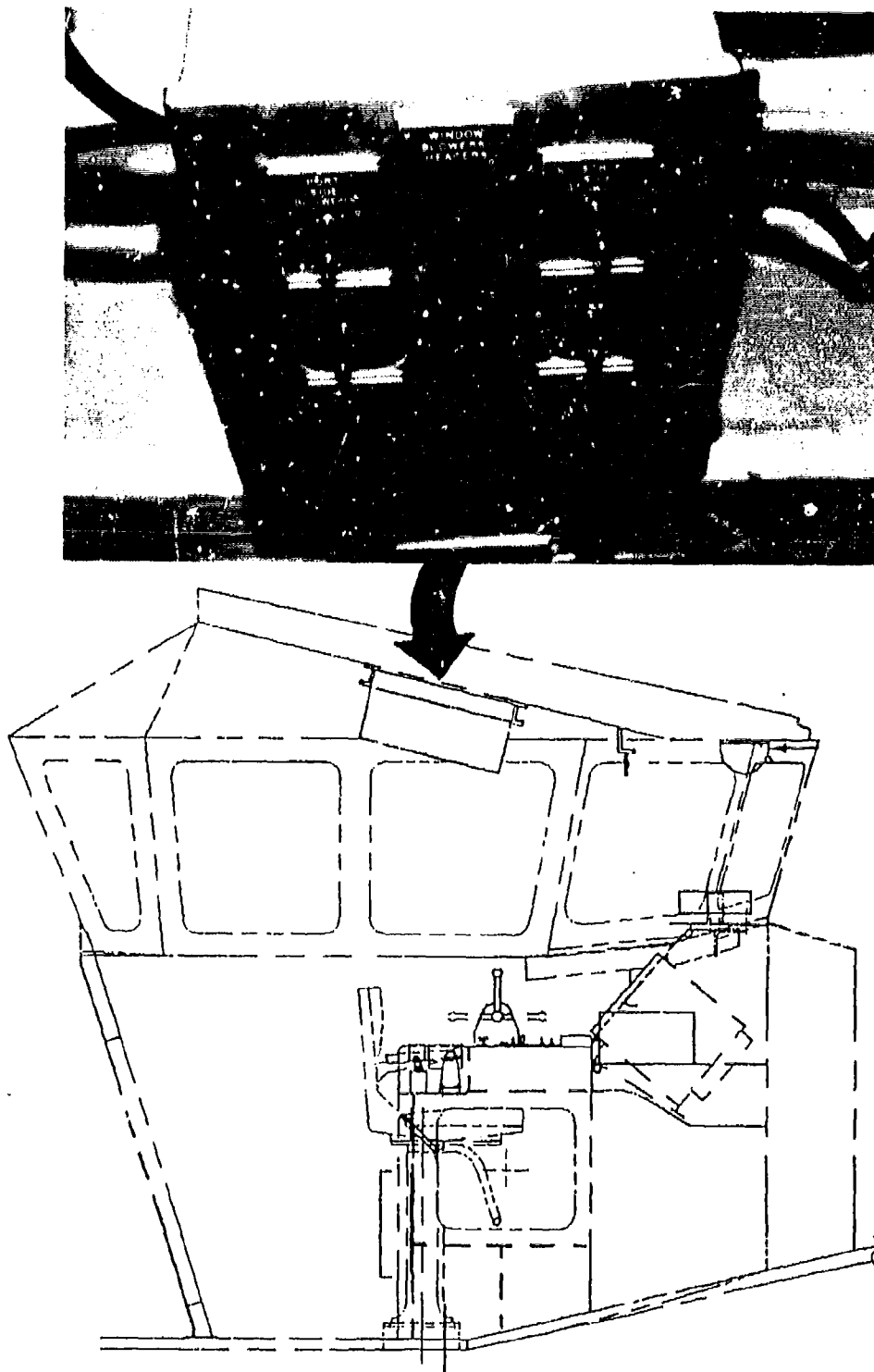


Figure II.22. Window/heaters junction box in enclosed bridge overhead.

11. HEATING, VENTILATION AND AIR CONDITIONING UNIT AND VENTILATION

It is desirable to provide air conditioning (AC) for the MLB. AC for the enclosed bridge personnel is as important as it is for electronic equipment. Not only does AC regulate temperature and ventilation, but if properly designed it could minimize the effects of exterior noise generated by the MLB or adjacent vessels.

For ventilation purposes, the fresh air supply should be 18 to 20 cubic feet, per minute, per passenger, or a minimum of 25% of the total airflow required to heat or cool the enclosed bridge space. The system should be quiet in operation and not interfere with crew communications.

It has not been demonstrated that a large capacity heat/air conditioner (HVAC) is necessary for the relatively small enclosed bridge. In most search and rescue sorties, the boat will be steered from the open bridge. The full capacity of the HVAC unit may not be used in most sorties. It is recommended that an alternate compact HVAC be tested in various environments (warm, hot, cold, humid, etc.) to assess its usefulness.

Problem:

- The HVAC mode switch is located on the port side of the dashboard.
- It has not been determined if the HVAC unit is satisfactory for the enclosed bridge. The noise level of the unit should not interfere with crew communications.

Approach:

- Since the unit is located in the overhead of the enclosed bridge, it is recommended that the HVAC mode switch be relocated to the unit itself. This arrangement would increase dashboard space and eliminate the need for additional wiring required in its current location.
- Alternative compact HVAC units should be tested and considered for enclosed bridge use. The use of a compact HVAC unit will increase overhead space (head clearance) and workspace.
- Remove the unit from the enclosed bridge. This option would increase the workspace and decrease the possibility of head injury.

12. LABELS AND LABELING

Following standard military guidelines, labeling techniques should be used to facilitate:

- ▶ Discrimination between individual displays.
- ▶ Identification of functionally related displays.
- ▶ Indication of relationship between displays.
- ▶ Identification of critical information within the display.

NAVAL BIODYNAMICS LABORATORY REPORT

Problem:

- As a general principle, control and display labels should be located in a consistent manner with respect to being above or below a control or display. Most of the labels are located below the control or display. For example, the navigation light and window blowers/heaters labels are located above the respective controls whereas most of the labels on both bridges are located below the control or display.
- In the current layout the colored plastic strips are attached to the exterior of the tachometer gauge display and exposed to the elements.

Approach:

- An effort should be made to locate labels in a uniform manner on both the open and enclosed bridges. It is recommended that all labels throughout both open and enclosed bridges be placed below the display or control mechanism.
- Navigation light switch panel: Rearrange the lighting switch panel located on the radar plotter enclosure on the open bridge (see Figures II.23 and II.24). The switches should be arranged to correspond to their positions on the boat. A diamond shaped arrangement would be appropriate and useful for crew operations (see Figure II.25). Additionally, all switches with dual controls, like the navigation light switches, should eliminate the up/down convention as this will change with the positioning of one set of switches. It is recommended that a horizontal configuration that uses LED lights to indicate the on/off condition be used in this application (Figure II.26). This prevents a confusing situation and requires the operator to physically notice the switches current operation. The addition of the LED indicator light will show the operator, immediately, the condition of the switch.
- Tachometers: The tachometer gauges in both open and enclosed bridges follow the recommended layout for dials and gauges. The use of colored range strips on the primary readout is to determine when the engine is performing within specified ranges (when it is less important to read specific values). The red strip indicates the range of revolutions per minute (rpm) that are considered lower and upper limits or out of engine tolerance parameters; the green strip indicates the range of rpm that is considered safe, normal or in-tolerance limits.
- The color coding of the tachometers gauges should be painted on the face (interior) of the gauge once the tolerance limits have been determined by test crew engineers. This would protect the color coding from inclement weather, water, moisture, and conditions of extreme heat or cold. The use of plastic colored strips is not recommended.

Human Factors Assessment of USCG 47-ft MLB

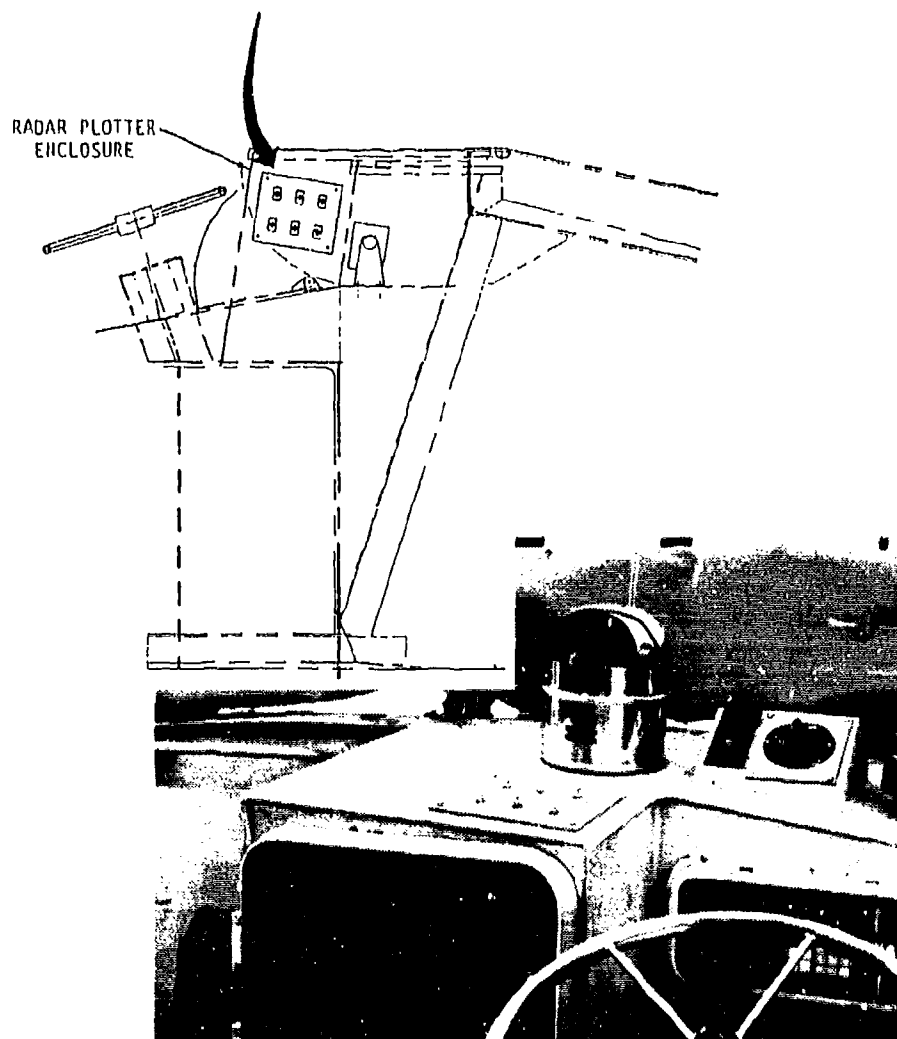
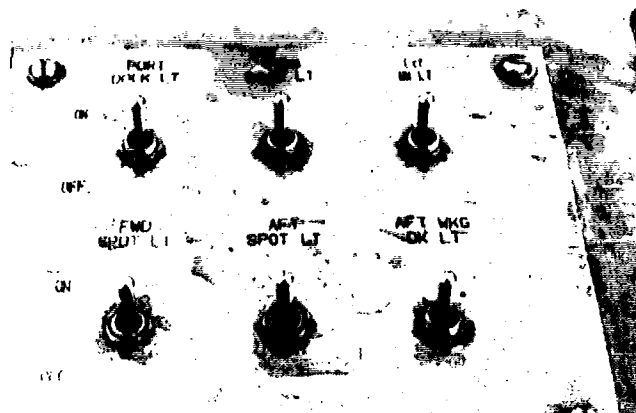


Figure II.23. Open bridge navigation and lighting switch panel.

NAVAL BIODYNAMICS LABORATORY REPORT

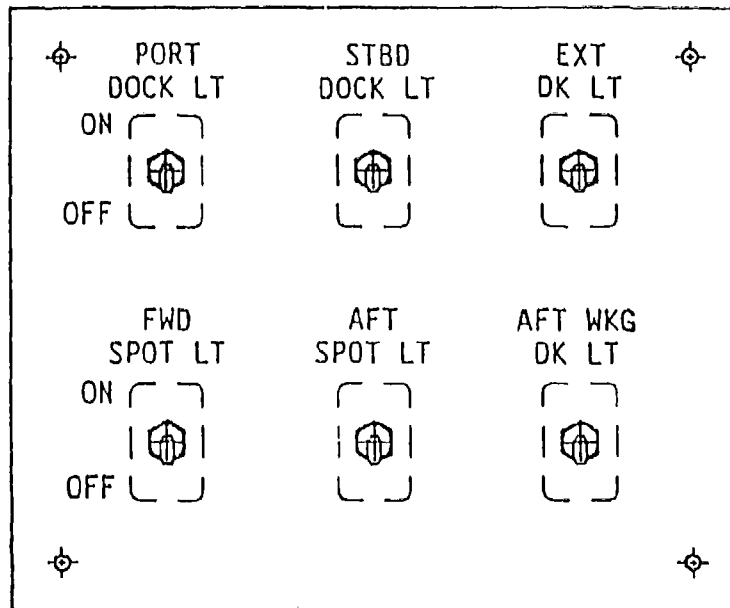


Figure II.24a. Current navigation and lighting switch panels on open bridge.

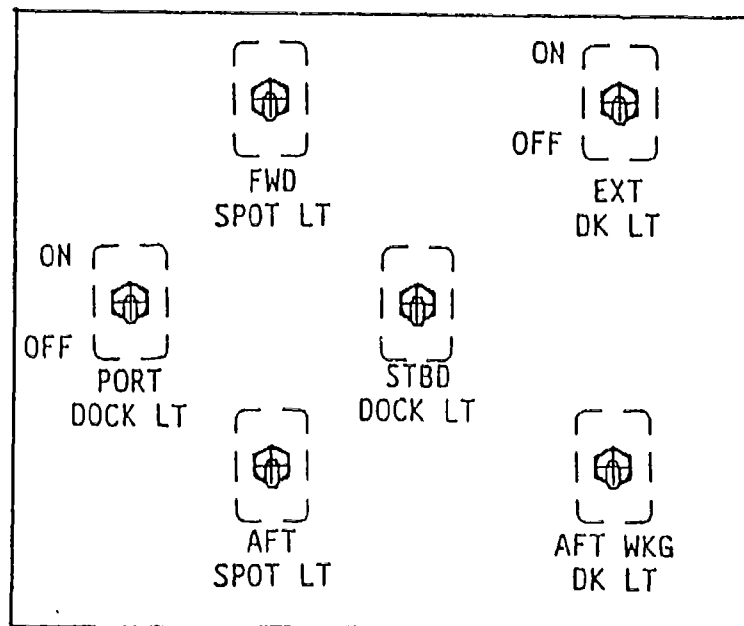


Figure II.24b. Proposed navigation and lighting switch panels on open bridge.

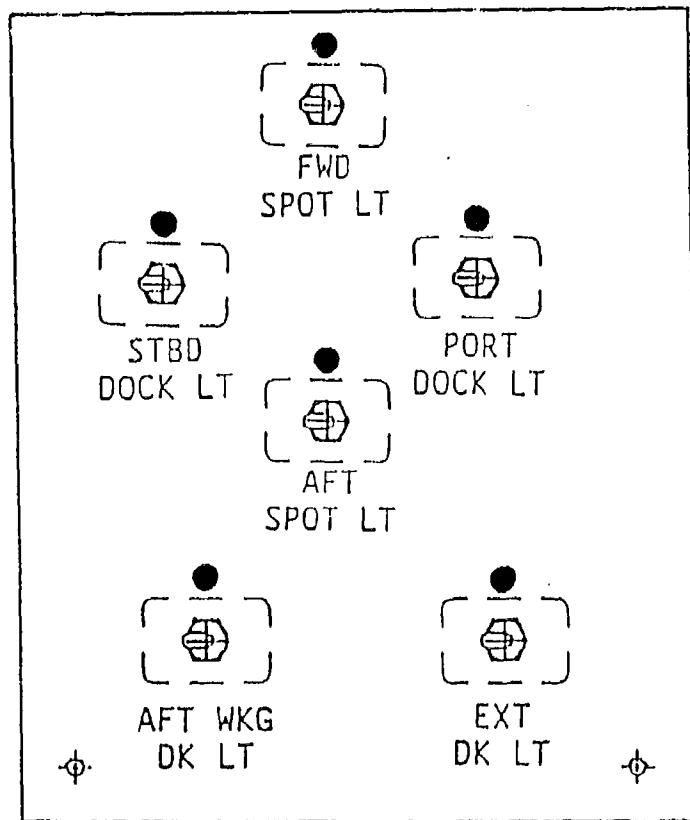


Figure II.25. Proposed navigation and lighting switch panel with LEDs.

- The green-red combination used on the current tachometer gauge is adequate in discriminating between the safe and unsafe rpm limits of the engine. However, it may be recommended that a third color be used in the gauge display. For example, the color yellow can be used to indicate marginal operating parameters. Figure II.26 illustrates both the current and the proposed color coding configurations for the tachometer gauges. The standard colors can be used for both round and half round gauges (discussed above).
- Situational factors (low ambient light/illumination, inclement weather, operator workload) will have negligible effects on the reading of the color coded tachometer gauges.

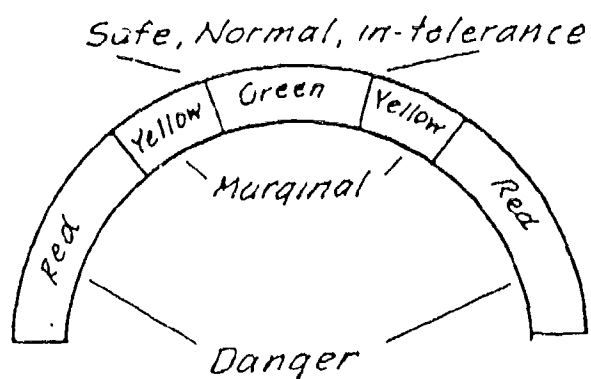
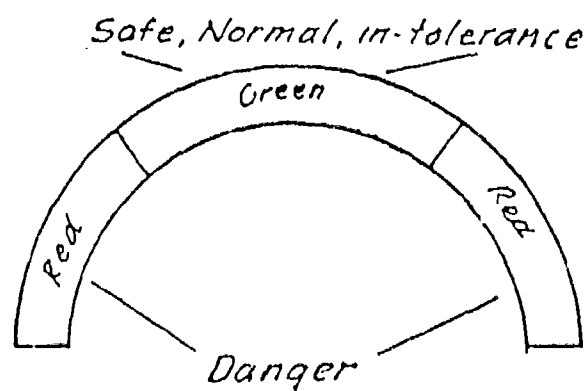


Figure II.26. Color codes for engine indicators.

APPENDIX

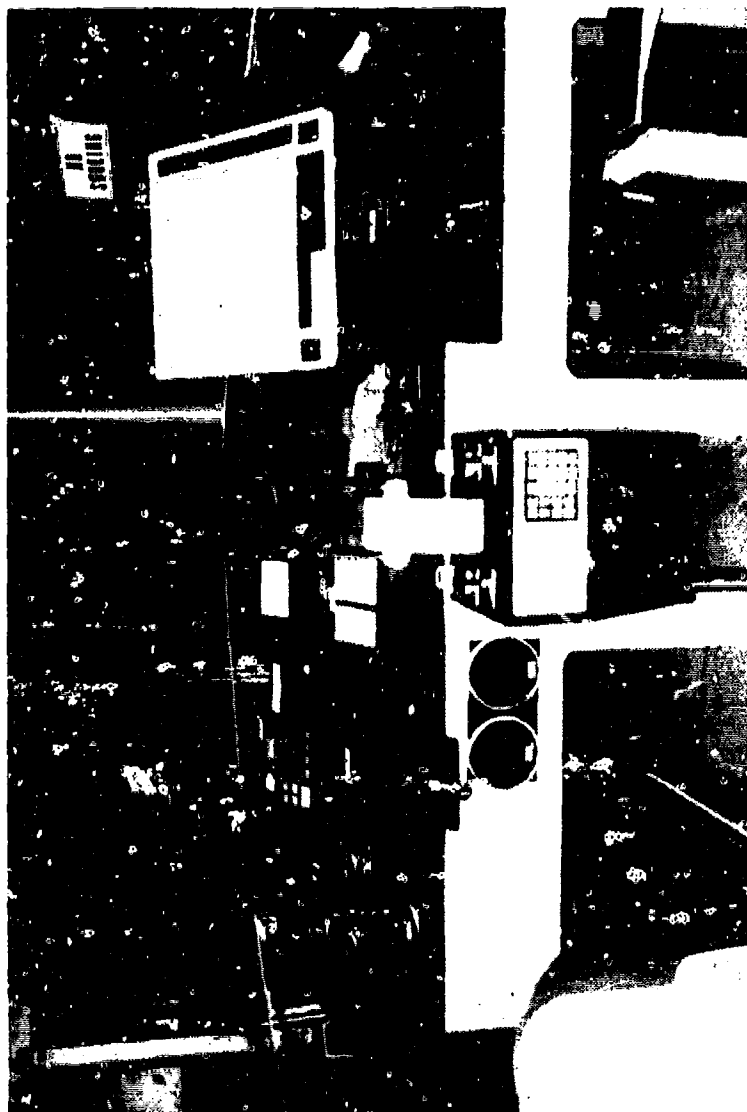


Figure A1. Enclosed bridge steering station mock-up (actual configuration).

NAVAL BIODYNAMICS LABORATORY REPORT

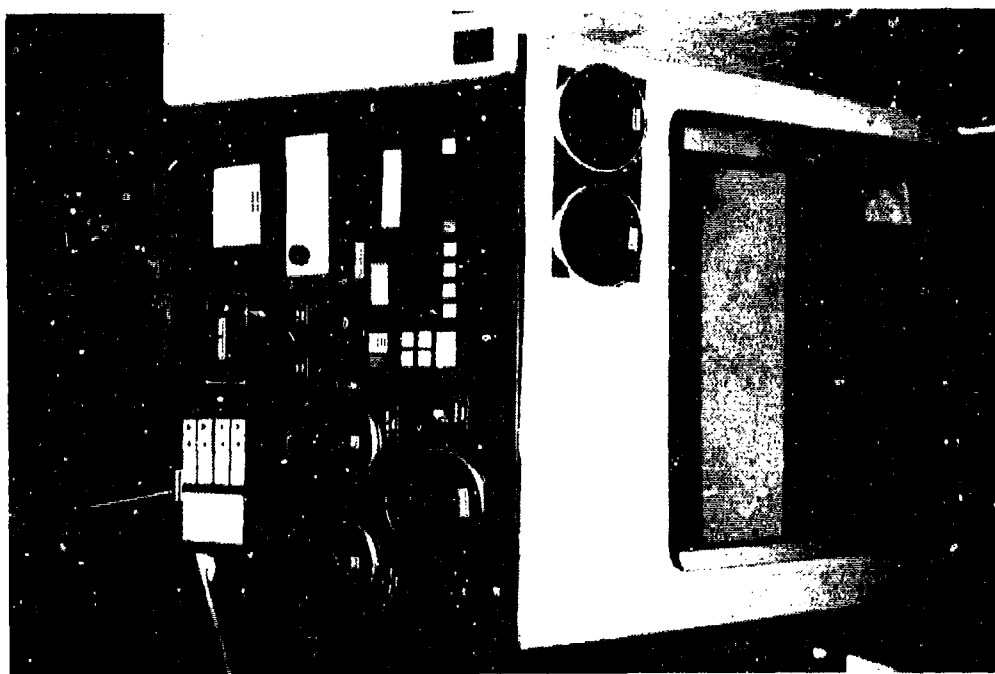
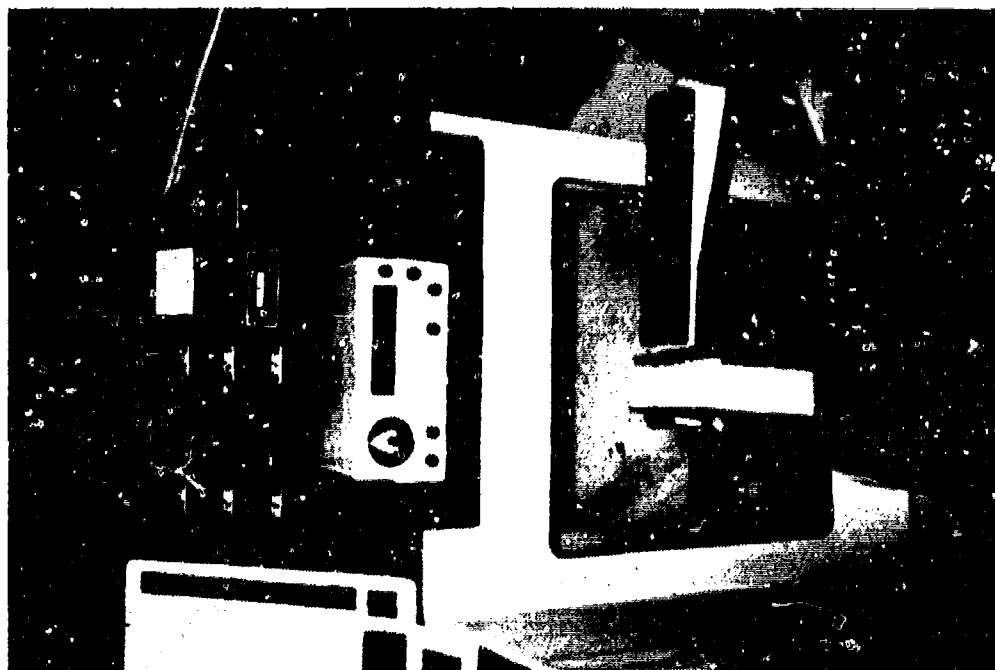


Figure A2. Enclosed bridge steering station mock-up (actual configuration).

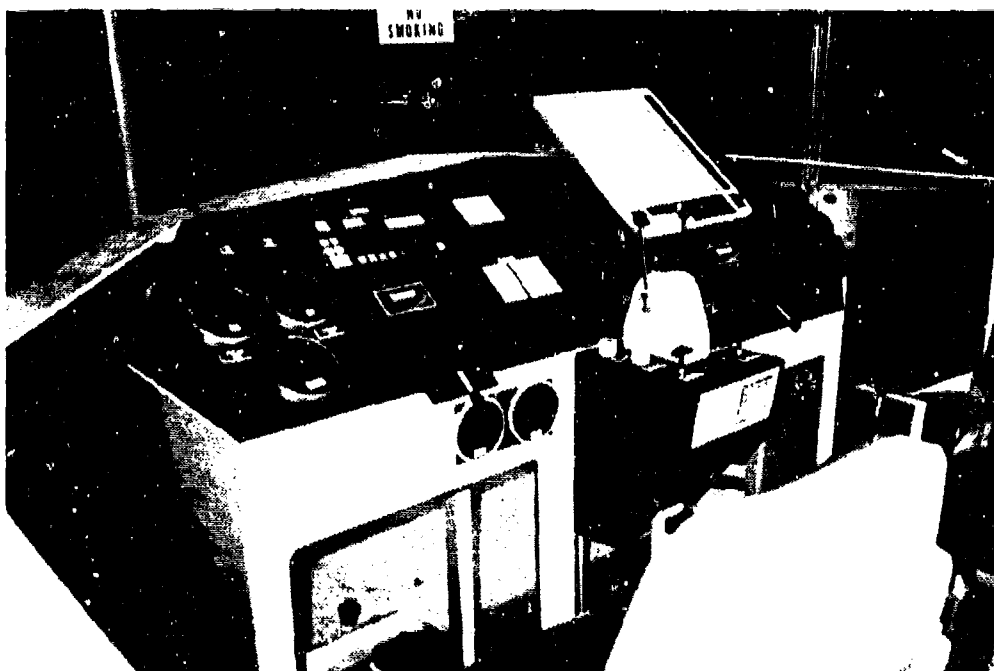
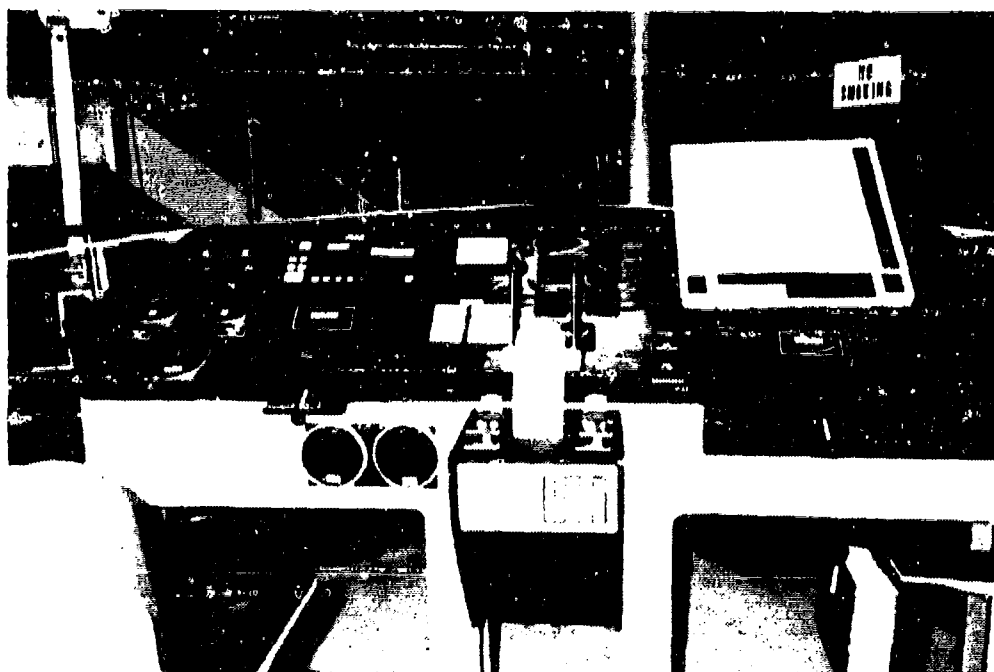


Figure A3. Enclosed bridge steering station mock-up (proposed configuration).

Human Factors Assessment of USCG 47-ft MLB

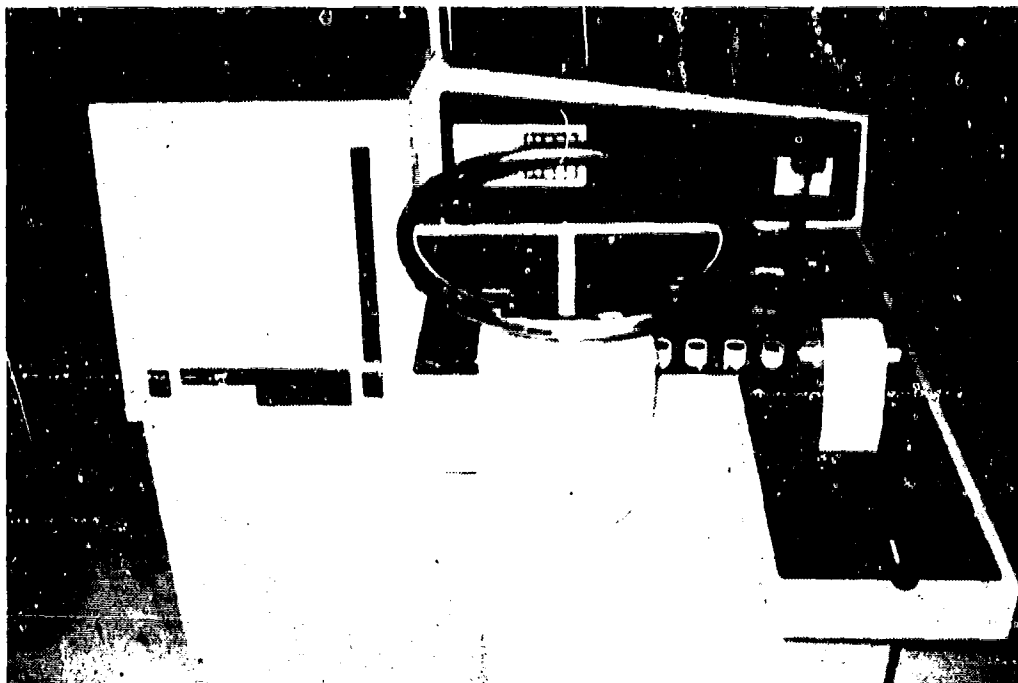


Figure A4a. Current starboard open bridge steering station mock-up.

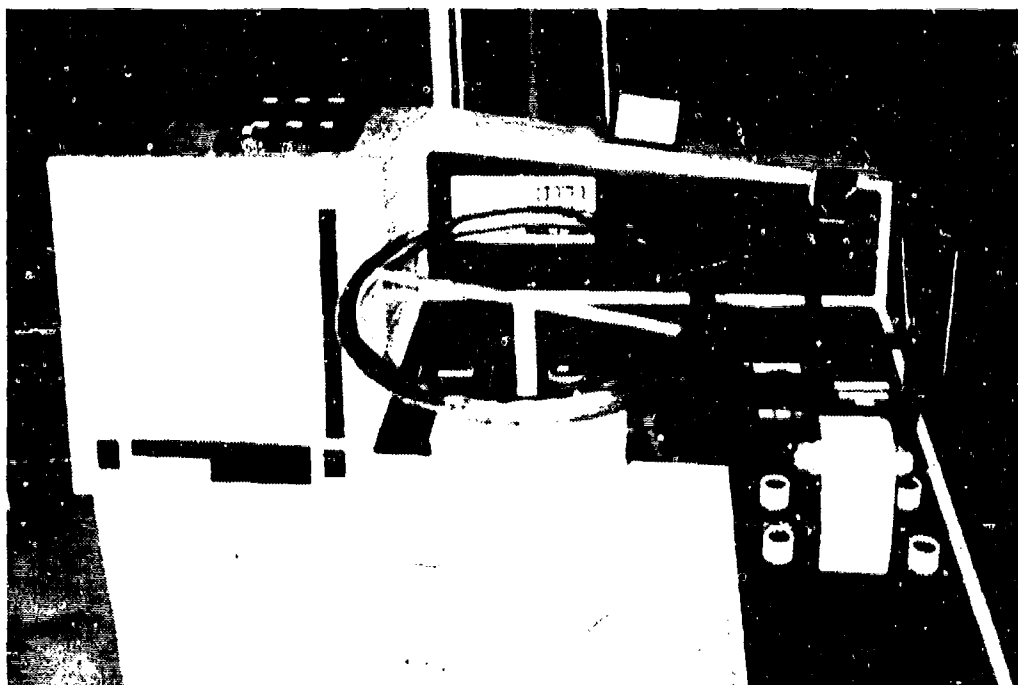


Figure A4b. Proposed starboard open bridge steering station mock-up.

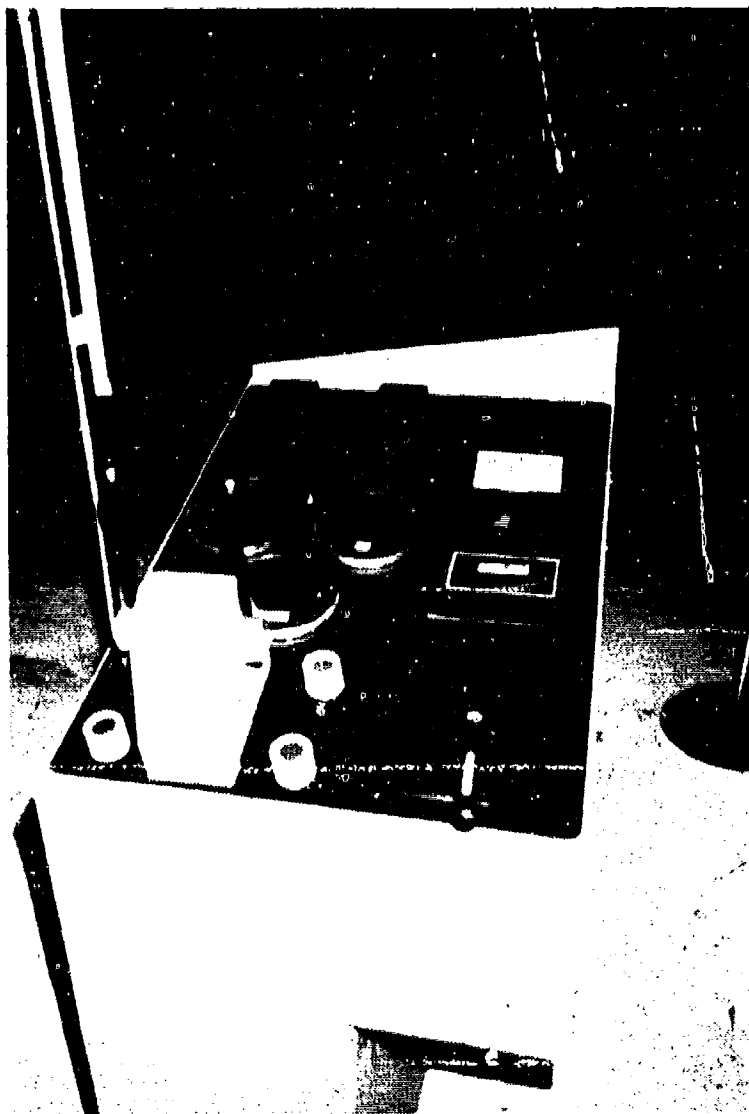


Figure A5. Port open bridge steering station mock-up (proposed configuration).